A minerals research contract report June 1982

DEMONSTRATING THE NOISE CONTROL OF A COAL PREPARATION PLANT VOLUME II:

LONG TERM TREATMENT EVALUATION

Contract H0155155 Bolt Beranek and Newman Inc. 10 Moulton Street Cambridge, MA 02238

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REPORT DOCUMENTATION PAGE	I. REPORT NO.	2.	3. Recipient's Accession No.
4. Title and Subtitibe Demonst; Preparation Plant Treatment Evaluati	- volume II. I	Control of a Coal	1 S. Report Date April 1982
Matthew N. Rubin 9. Performing Organization Name and			8. Performing Organization Rept. No. BBN Report No. 4922
Bolt Beranek and M 10 Moulton Street Cambridge, MA 022	Jewman Inc.	•	10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) USBM No. HO155155 (G)
Office of the Assi Bureau of Mines Department of the	stant Director		13. Typo of Report & Period Cavered Final Report 14.
15. Supplementary Notes		0	

16. Abstract (Limit: 200 words)

90272 - 101

This report summarizes the work performed under USBM Contract No. HO155155. The purpose of this work was to obtain operational data on retrofit noise control treatments suitable for use in coal preparation plants. This data was obtained by evaluating the performance of four categories of noise control treatments which were installed in a commercial coal preparation plant. The four categories of treatments were resilient screen decks, resilient impact pads, chute liners, and curtains.

The selection, installation and initial evaluation of the treatments was documented in the Volume I report issued in 1977. This Volume II report summarizes the results of the long-term evaluation of the original treatments, as well as some additional tests which were conducted on elastomer-clad (resilient) screen decks.

This project demonstrated the feasibility of a number of retrofit noise control treatments, some of which also proved to be quite durable over the long term.

37. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

Coal Preparation Plants Noise Control

c. COSATI Fleid/Group

18. Availability Statement		1
- Contained	19. Security Class (This Report)	21. No. of Pages
	UNCLASSIFIED	91
	20, Security Class (This Page)	22. Price
(See ANSI-Z39.18)	UNCLASSIFIED	1
See Instructions on Reve	780	OPTIONAL FORM 277 (4, 27)

OPTIONAL FORM 272 (4-77) (Farmerly NTIS-35)

FOREWORD

This report was prepared by Bolt Beranek and Newman Inc., Cambridge, MA under USBM Contract No. HO155155. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of Pittsburgh Research Center with Tom Bobick acting as Technical Project Officer. John Connelly was the contract administrator for the Bureau of Mines. This report is a summary of the work recently completed as part of this contract during the period October 1977 to August 1981. This report was submitted by the author in April 1982.

The author would also like to acknowlege the assistance of Mr. D. Hambric of Morris-Coker, Inc., Mr. D. Hurley of the J.A. Reading Co., Mr. J. Kovac of the USBM, and Mr. D. Zinko of Consolidation Coal Co.

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1. INTRODUCTION

1.1 Background

It has long been acknowledged that the high noise levels commonly encountered in modern coal preparation plants can pose a serious risk to the hearing ability of plant workers. As a result, various noise control techniques and materials have been proposed or marketed in recent years to reduce the noise exposure of plant personnel. Since many of these techniques and materials were based on experience in other industries, it was often difficult for coal preparation plant operators to determine whether these treatments were suitable for their own plants. Recognizing this, the U.S. Bureau of Mines initiated this project to obtain operational data on several techniques and materials which could assist preparation plant operators in selecting noise control treatments appropriate for their plants.

It was determined at the outset that this project should focus on retrofit of existing plants and the data should be obtained through actual in-plant tests. Although it was clear that such tests do not permit the same degree of control and documentation as laboratory tests, it was felt that data obtained from actual use in a commercially operating preparation plant would be more realistic, and thus more useful to the industry.

This project consisted of the following tasks:

- 1. Selection of a demonstration plant.
- Noise and operational survey of demonstration plant.
- 3. Selection and design of noise control treatments.
- 4. Installation and evaluation of noise control treatments.
- 5. Long-term monitoring and evaluation of treatments.

The results of Tasks 1 through 4 were documented in "Demonstrating the Noise Control of a Coal Preparation Plant, Vol 1. Initial Installation and Treatment Evaluation" (BBN Report No.

3631).* This current report is a follow-up to the Volume 1 report and documents the results of Task 5. In addition, the results of a set of supplementary elastomer-clad screen deck tests (the need for which was identifed under Task 4) are also documented in this report.

1.2 Project Summary

As discussed above, the first step in this project was to select a demonstration plant. Two criteria served as a basis for selecting the plant. First, the plant staff must be willing to cooperate, which involved not only the installation of the treatments but record keeping as well. Second, the plant should have a representative selection of coal cleaning equipment. Based on these criteria Consolidation Coal's Georgetown Preparation Plant was selected as the demonstration plant for this project.

A noise and operational survey was conducted to (1) identify the major noise sources within the plant, (2) determine the noise exposures of plant personnel, and (3) obtain operational data on maintenance, access, and visual monitoring requirements. Since the selection of equipment to be treated was to be based on worker exposure, as well as the need for performance data on a variety of commercially available noise control materials, plant areas were categorized as follows:

- Type I Continuous exposure area, in which at least one person is located for their entire shift.
- Type II Frequent exposure area, in which mobile personnel are found for 1/3 to 2/3 of their shifts.
- Type III Limited exposure area, in which personnel are located for one hour or less per shift.

^{*}Hereafter referred to as the Volume 1 Report.

Those pieces of equipment located in Type I or II areas and having high sound levels were considered high priority sources in the selection of equipment for treatment.

The majority of the noise control treatments selected for use in the demonstration plant fall into four categories:

Resilient screen decks

Resilient impact pads

Chute liners

Loaded-vinyl curtains.

Screen decks with resilient (rubber or urethane) top surfaces were installed in several areas to reduce the noise generated by the coal or refuse impacting the original steel screen decks. While these tests demonstrated that such screen decks can reduce this coal/screen deck impact noise, the tests also confirmed that the full potential of these screens could not be achieved without treatment of the other noise sources associated with vibrating screens. These other sources include impacts at the infeed, discharge, and bottom deck and/or pans, and the drive mechanism for the high speed vibrators. From an operational and durability point of view, two areas of concern were revealed by the testing. The first is screening efficiency, which is a function of the amount of open area originally designed into the screen surface and the amount of blinding (i.e., plugging of holes by near-sized pieces) that occurs during operation. In these tests blinding appeared to be a major problem only in the older crank-arm type screens, while open area can be a problem on any screen depending on how heavily loaded the screens are. second area identified in the testing was a problem with delamination of the resilient layer on the elastomer-clad steel decks. In several screen decks the resilient top layer had completely separated from the steel punch plate long before significant wear could be observed in the elastomer layer.

As a result, additional screen deck tests were undertaken in four different preparation plants. The results of these tests indicated that significant improvements have been made since the initial tests in bonding the resilient top layer to the steel punch plate, particularly for the urethane-cast-to-steel decks. These tests took place after the completion of the Volume 1 report and are described in more detail in Sec. 3 of this report.

Resilient impact pads were installed at the discharge of various belts, basket elevators, screens, and chutes to reduce the noise generated when the material flow impacted the steel chute walls. Experience at this demonstration plant indicated that these pads were not only effective in reducing the noise resulting from the impact of the material flow, but can be a cost-effective solution. That is, when designed and installed properly, the service life of these impact pads can sufficiently exceed that of the original steel plates to compensate for their relatively high initial cost. These tests also confirmed that impact angle and pad thickness are primary design parameters in these installations and must be carefully chosen to achieve maximum performance from the pads.

Various types of chute liners were experimented with in this project. As was expected, the resilient liners provided the greatest noise reduction. Rigid chute liners only tend to be effective, from a noise control point of view, in closed chutes where there was significant re-radiation from the original chute walls. The ultra-high molecular weight polyethylene (UHMWPE) plastics were found to be extremely durable when material is primarily sliding over them, but tend to wear quickly with turbulent or bouncing flows. Finally, these tests also confirmed that simply installing covers on open-top chutes can be a very effective, yet relatively low cost, noise control treatment. It should be recognized, however, that this treatment can make

visual monitoring more difficult and therefore must be carefully evaluated on a case-by-case basis.

There are a number of aspects inherent in loaded-vinyl curtains that make them particularly useful for enclosing noisy equipment in coal preparation plants, and in existing plants in particular. Primarily, these are the adaptability in dense complicated equipment layouts, and easy opening or removal for equipment maintenance or replacement. However, while the use of flexible loaded-vinyl curtains has been fairly common in other industries, the questions of noise reduction, durability and visual access needed to be answered before they could be considered suitable for coal preparation plants. The curtains used in this project proved to be effective and durable over the long term. The question of reduced visual access (which exists any time a piece of equipment is enclosed) is not so easily answered, however, and must be addressed on a case-by-case basis.

1.3 Report Organization

Section 2 of this report deals with the specifics of the treatments installed at the demonstration plant. The equipment, treatments and initial test results are reviewed briefly in this section (the details of the plant flow sheet, equipment and treatments are addressed in the Volume 1 report). Also discussed in this section are the results of the follow-up visits to the plant and the effect of wear, equipment and operational changes on the sound levels within the plant. Finally, a number of suggested modifications or additions to the treatments, based on the results of the tests, are also discussed.

Section 3 describes the additional screen tests which were conducted in four separate preparation plants. Section 4 includes conclusions for both the initial tests and the separate screen tests and suggests areas for future research.

2. GEORGETOWN PREPARATION PLANT

2.1 Background

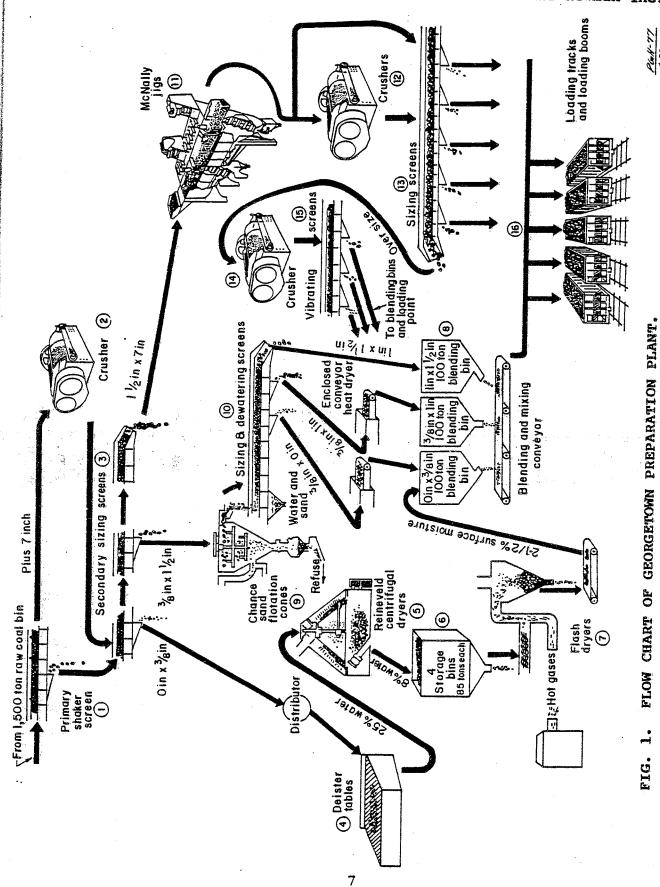
2.1.1 Plant description

The Georgetown Preparation Plant was built in 1951 and was designed to process 1650 tons per hour of raw coal. Although the plant was originally designed to clean both surface and underground coal, there has been a shift toward surface mined coal during the course of this project. This shift in the plant feed size will be discussed in Sec. 2.2.2. since it had a measurable effect on the sound levels within the plant.

The plant was designed with three basic cleaning circuits, $7 \times 1-1/2$ in., $1-1/2 \times 3/8$ in. and $3/8 \times 0$ in. As can be seen in Fig. 1, the raw coal entering the plant is first fed to a primary shaker where the oversized material is scalped off and crushed. The secondary sizing screens then separate the flow into the three size classifications. The large material from the top deck of the secondary screens is cleaned in two McNally jigs, dewatered over screens, and then sized and/or crushed before loadout. The middle size cut from the secondary screens is cleaned in two chance sand floatation cones. The clean coal is then dewatered and sized on two clean coal desanding shakers and either sent to centrifuges for drying (for the smaller material) or loaded out directly (for the larger material). The fine coal from the secondary screens is cleaned on Deister tables and dried in Reinveld centrifugal dryers before loadout.

Since the Volume 1 report was issued, the plant has also installed a thermal dryer and a froth floatation disc filter system for recovering and drying the fine sizes.

The Georgetown Plant is composed of three contiguous buildings. Building A contains the coal infeed and cleaning equipment: raw coal belts, primary and secondary screens, McNally



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jigs and chance cones. Building B contains the dewatering equipment as well as the dryers and furnaces. Building C is the load-out plant and contains the final sizing and loading facilities, clean coal crushers and storage bins. Although there is some overlap (for example, the Deister tables which clean the fine coal are located in Building B), Building A contains the cleaning equipment, Building B contains the dewatering and drying equipment, and Building C is the loadout plant. The locations of the major processing equipment are shown in the floor plans, Figs. 2 through 10.

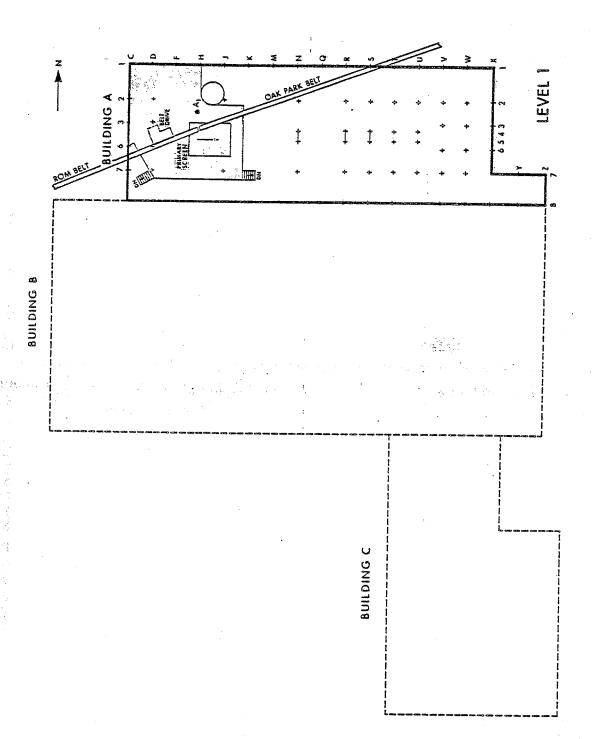
The plant personnel can be divided into two categories: stationary workers and mobile workers. The stationary workers, who remain at one location throughout their shift include: the picking table operator, washbox (jig) operator, dryer operator, Deister operator, loadout operator, car shakeout operator and the warehouse tender. The roughly 19 mobile workers, which move throughout the plant during their shifts, include the mechanics, electricians, clean-up, sampler, oiler, inspectors, and the foremen.

2.1.2 Plant survey

A noise and operational survey of the plant was made at the beginning of the project to assist in selecting the noise control treatments. Specifically, the noise survey was intended to (1) identify the major noise sources within the plant and (2) to provide baseline noise levels to be used in the acoustic evaluation of the treatments. The survey also detailed some operational information to be used in the selection of the treatments, such as, which areas required ready access for maintenance or continuous visual access.

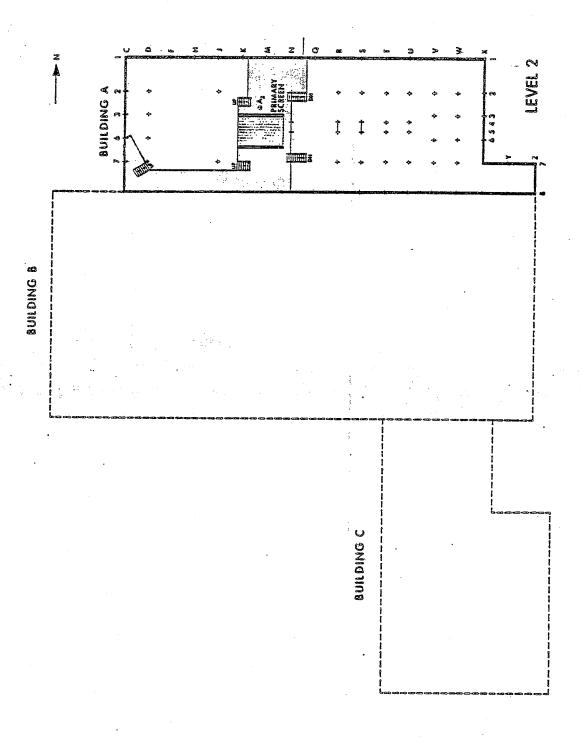
Table 1 summarizes the results of the baseline noise measurements. Listed in the table are the measurement positions, the major pieces of operating equipment in the area and the

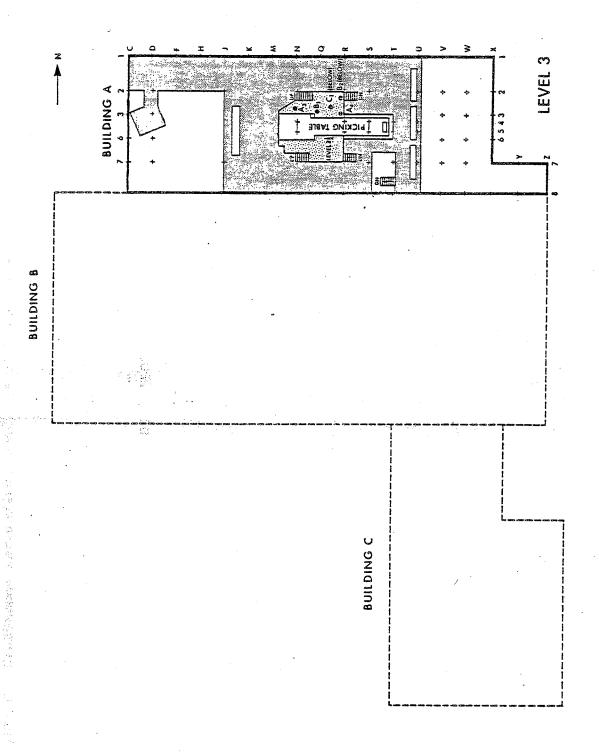
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FLOOR PLAN OF LEVEL GEORGETOWN PREPARATION PLANT. 7 FIG.

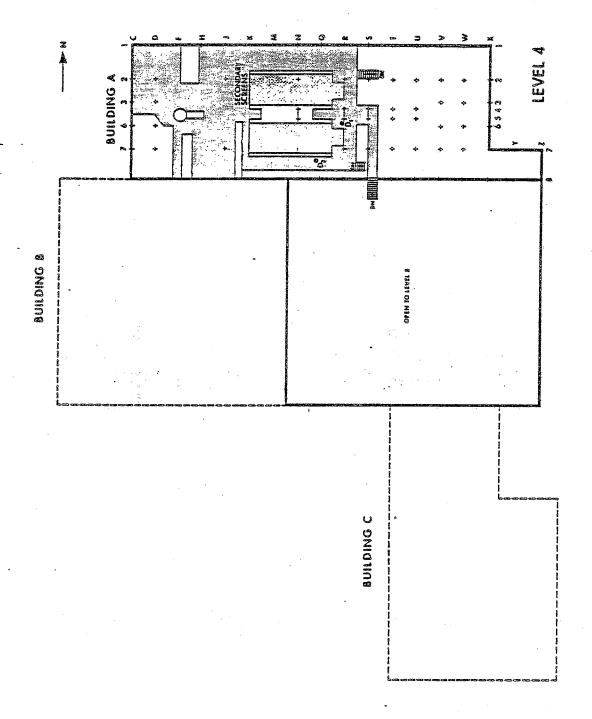




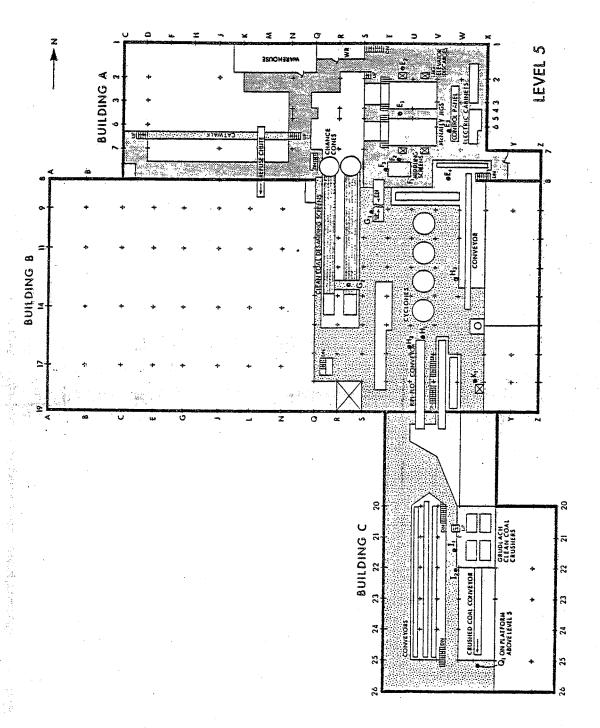


FLOOR PLAN OF LEVEL GEORGETOWN PREPARATION PLANT.

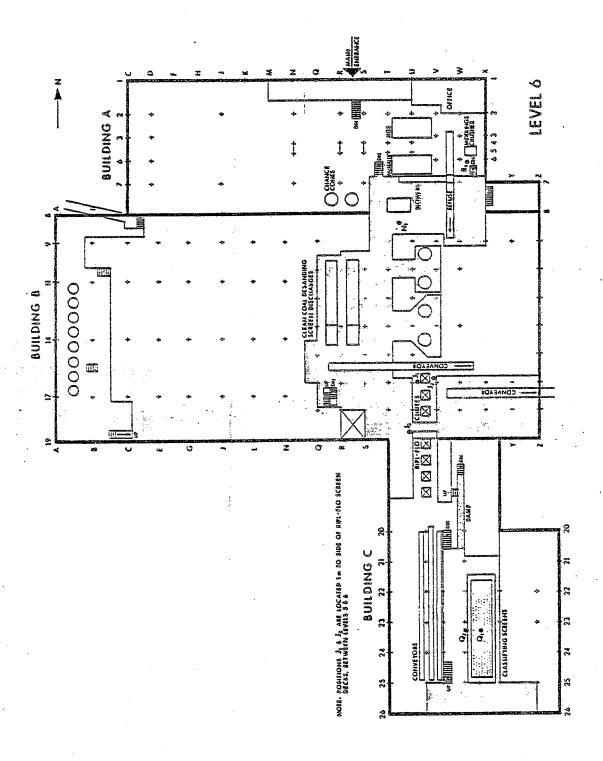






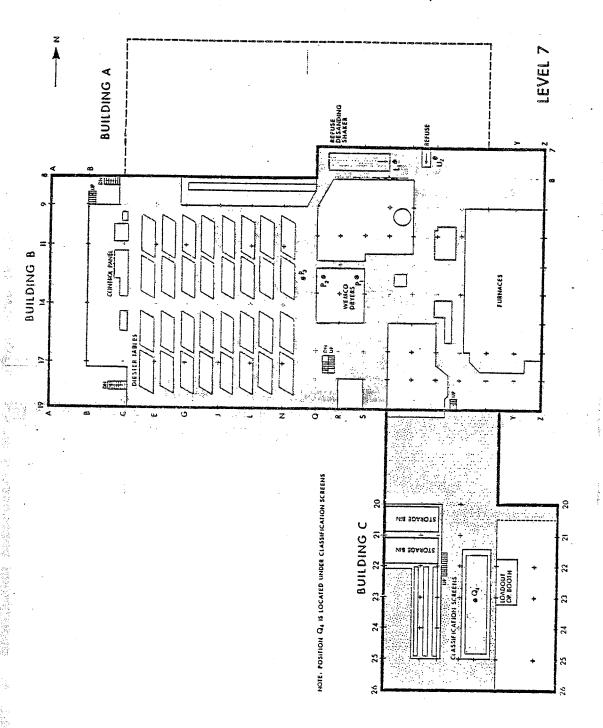


GEORGETOWN PREPARATION PLANT. FLOOR PLAN OF LEVEL 5. FIG. 6.



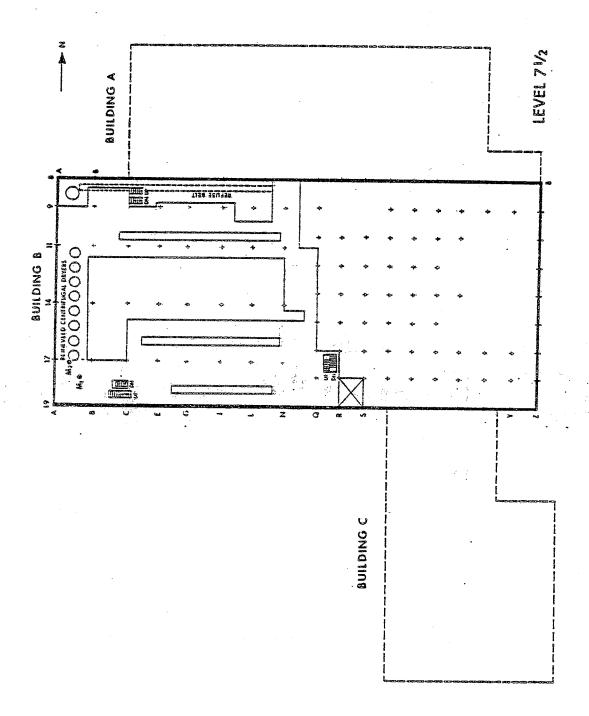
FLOOR PLAN OF LEVEL 6. GEORGETOWN PREPARATION PLANT. FIG

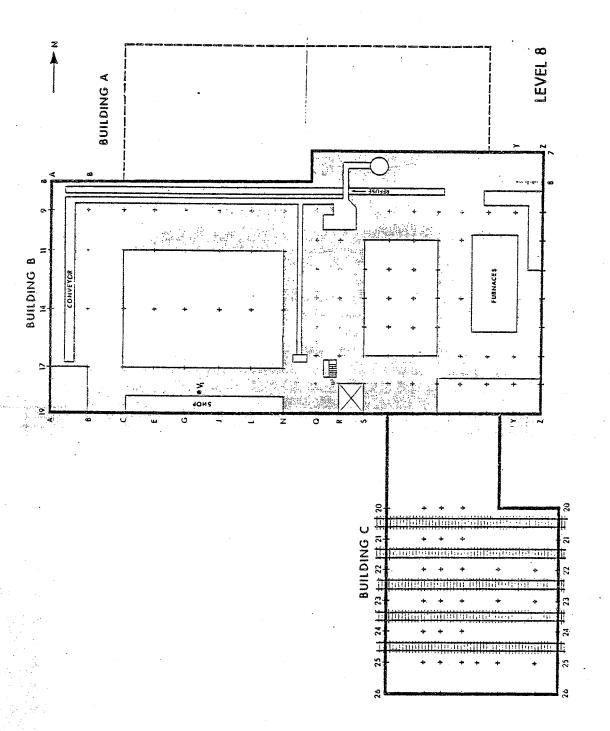
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FLOOR PLAN OF LEVEL 7. GEORGETOWN PREPARATION PLANT, **.**







FLOOR PLAN OF LEVEL FIG. 10. GEORGETOWN PREPARATION PLANT.

TABLE 1. SUMMARY OF MEASURED SOUND LEVELS.

		Measured Sound Levels, dB(A)		

Equipment	Measurement Position	Full Capacity	No-Coal[1]	No-Coal [2]
Belt Drives	A,	92	88 - 91	85
Primary Shakes	Ag	96	90 - 94	90 - 92
Picking Table	A ₃	94	91	88
Boney Coal Crusher	A _u	93	90	86
McLanshan Rock Crusher	S _L	93 - 100	91	71
	B ₂	92	89	78
	c,	92	90	77
Secondary Sizing Screens	D ₁	96	88	79
	D ₂	95 - 97	87	76
	D3	96	1040	
McMally-Saum Jigs	E ₁	95	92	81
,	E _z	97	92	83
	E3	96 - 95	90	-
Middlings Vibracors	F,	96	-	88
1	F ₂	95	44	93
· ·	F ₃	94 - 97	***	86
Clean Coal Desending Shakers	e ¹	96 - 97	92	80
	. G ₂	96	. 92	84
Ripl-Flo Screen Feed Conveyor	H,	95	92	80
	H ₂	98	91	80 😁
Dryer Feed Conveyor	H ₃	90		
Grundlack Crushers	r,	96	86	80
•	Ľ2	049	85	80
Ripl-Flow Screens	J	101	97	96
	J ₂	100	95	96
Vacuum Pump	K ₂	95	96	92
Refuse Desending Shaker	L	97	96	96
Reineveld Dryers	H.	97 - 101	95	92
	M ₂	99 103	95	92
Jig Blowers	M _q	99	100	102
Weaco Dryers	P ₁	95	92	****
	P ₂	96	***	
	P 3	96		C=0
Heed End Crushed Coal Belt	Q_1	100		•••
Classifying Shakers	Q ₂	102	***	92 - 96
	o,	104	-	-
	Q,	103 - 104	****	C+40
Jig Feeder	R ₁	96	,ena	
Rail Car Unicader (shake- out)	s,	111 - 113		comp
Syntrom Feeders	Ŧ,		108	~~

^{[1] &}quot;We-Coal" refers to the operation of the equipment, in conjunction with adjacent equipment, without coal flow.

^{[2] &}quot;No-Coal (alone)"refers to the same operating condition as [1], except all adjacent equipment is shut down.

A-weighted sound levels under full operation (with and without coal) and with the equipment operating alone without coal. The actual locations of the measurement positions are shown in the floor plans (Figs. 2 through 10). A detailed discussion of the results of the baseline noise survey can be found in Sec. 3.1 and Appendix B of the Volume 1 report.

Since the selection of the equipment to be treated was to be based on worker noise exposure, as well as the desire for operational experience with a variety of commercially-available noise control materials, the ranking of equipment had to be based on worker exposure as well as absolute noise level. To assist in this rank ordering, the plant was divided into various areas which were then classified according to the amount of time plant personnel spent in the area. The area classifications were:

- Type I Continuous exposure area, in which at least one person is located for their entire shift.
- Type II Frequent exposure area, in which mobile personnel are exposed for approximately 1/3 to 2/3 of their shift.
- Type III Limited exposure area, in which plant personnel are located for one hour or less per shift.

Table 2 lists the major pieces of operating equipment within the plant, their representative sound levels and the exposure classification of the areas in which they are located. A complete discussion of the classification of the plant work areas is presented in Appendix B of the Volume 1 report. The sound levels listed in Table 2 are either for the individual pieces of equipment or for the area as a whole if several pieces of equipment ordinarily operate together and contribute to the noise exposures of the plant personnel. The sound levels in Table 2, therefore, represent the actual sound levels to which the workers are exposed during normal plant operation.

TABLE 2. NOISE SOURCES AND EXPOSURE CLASSIFICATIONS.

Equipment Description	Representative Sound Level in dB(A)	Exposure Classification
Oak Park Belt Drive	92 - 94	III
Rom Beic Drive	91	III
Primary Screen	94	II
Picking Table	94+	î
McLanahan Rock Crusher	Impulses to 100	1
Secondary Sizing Screens	95 - 97	II
McNally-Baum Jigs	94 - 97	Î
Middling Shakers	94 - 97	I
Jeffrey 5 ft × 9 ft Feeders	95	III
Clean Coal Desanding Screens	96 ~ 97	II
Ripl-Flo Feed Conveyor	94 95	II
Dryer Feed Conveyor	90	III
Grundlach Coal Crushers (4)*	96	II
Ripl-Flo Screens (7)	101	II
Vacuum Pump	95	III
Come Refuse Desauding Screen	97	III
Reineveld Centrifugal Dryers (7)	97 ~ 103	II
Wemco Dryers (6)	95 96	II
Classifying Screens	102 - 104	II.
Rail Car Shaker	111 - 113	II
Flash Dryers	T 7.2	III
Middlings Crusher	· · ·	III
Jig Refuse Shaker	96	III
Syntron Feeders	108	III
Jig Blowers	39	III

^{*}Numbers in parentheses refer to the number of individual machines of each type in use.

In selecting equipment to be treated, equipment with both high noise levels and Type I or II classification were generally given priority.

2.1.3 Treatment selection

As stated in Sec. 1.1, the selection of treatments for this project was based on the need of plant operators for operational information on the available noise control materials, as well as the desire to provide some measure of noise reduction in the demonstration plant. The treatments that were installed and evaluated can be categorized into the following four areas:

- Resilient screen decks.
- Resilient impact pads.
- 3. Chute linings.
- 4. Loaded-vinyl curtains.

Vibrating screens are probably the largest and most difficult noise problem in coal preparation plants in general, and in this demonstration plant in particular. For the older, low-speed, crank-arm shakers, the primary noise generating mechanism is the impact of the material flow on the screen deck. In modern, high-speed, eccentric-weight screens, the noise generated by the drive mechanism can also be a major contributor. A number of manufacturers produce screen decks with a resilient (elastomeric) top surface which is intended to reduce the impact noise generated by the material flowing over the deck. In addition to the noise reduction potential, some of these resilient screen decks were also purported to provide extended screen life and reduced blinding as compared to ordinary steel punch plate screens.

To evaluate these features, a variety of resilient screen decks were selected for testing. In addition, one experimental damped screen deck was also tested at the beginning of the project. Since the demonstration plant only had a limited number of eccentric-weight screens, and a redesign of the drive mechanism was beyond the scope of this retrofit project, resilient screen decks were the primary screen treatments investigated.

Although the initial tests in the Georgetown Plant verified the noise reduction potential of such resilient screen decks, several operational problems were identified. These were blinding (particularly for the thicker decks on the crank-arm shakers), and delamination of the resilient top surface of the elastomer-clad-to-steel decks. To determine if these operational problems were common to other plants, and if the newer resilient

decks which had come on the market during the monitoring period had improved over those initially tested, supplementary screen deck tests were proposed and conducted in four other preparation plants. These tests, which are discussed in Sec. 3, indicated that some of the newer materials (particularly the urethane-cast-to-steel decks) had improved significantly in terms of preventing delamination.

Several types of chute linings and impact pads were selected for evaluation, because the noise generated by the impact of material flow on steel chute walls is a major noise problem in many plants, including the demonstration plant. Information was also sought on the service life of these materials since some are sold on the basis of providing extended service life, as compared to ordinary steel, in addition to noise reduction.

The chute lining materials evaluated included ultra-high molecular weight (UHMW) plastic and ceramic tiles as well as rubber. Installations were made in both open and closed chutes. As expected, the resilient materials have a greater noise reduction potential than the rigid materials. All of these materials had a limited effectiveness in open chutes due to the noise inherent in the material flow. The UHMW plastic was found to be quite durable with smooth, sliding flows, but wore quickly when exposed to tumbling or impacting flows. The ceramic tiles, while more durable in tumbling flows, did show evidence of cracking over time. The rubber-lined chutes, which handled 1-1/2 × 3/8 in. material, also proved to be quite durable.

The impact pads selected were primarily rubber or polyurethane compounds. Both flat or profiled (ribbed) configurations were used, depending upon the impact angle. In general these pads can be very effective in reducing the impact noise. While the service life was found to depend heavily on correct installation, some of the impact pads have significantly outlasted the original steel plate. n(

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e ile The use of flexible curtains to enclose or separate noisy equipment, which cannot be treated effectively through other means, has a number of advantages over rigid enclosures. These advantages, which include adaptability to dense, complicated equipment layouts and ease of opening or removal for access or maintenance, are particularly desirable in coal preparation plants. Because of this, and the fact that such curtains have been used successfully in other industries for years, they were selected for use in a number of areas of this demonstration plant. Of concern in this evaluation was not only their noise reduction potential but how durable they were and whether their use imposed any significant operating restrictions on plant personnel.

The curtains used in this project (primarily fiberglass reinforced 3/4 lb/sq ft loaded-vinyl) not only proved to be effective from a noise control point of view but very durable as well. While the presence of the curtains did require that operators open them to make visual inspections, this is far easier than with rigid enclosures, and did not have a major impact on plant operations.

2.2 Treatment Evaluation

This section reviews how the noise control treatments performed during the course of the project. A complete description of the initial installation and evaluation of the treatments is presented in the Volume 1 report. This section is divided into two subsections; the first discusses (on an area by area basis) how each of the major treatments performed, and the second section summarizes the changes in the plant sound levels which took place during the course of the project.

2.2.1 Operational evaluation

Primary Shaker Screens

During the initial phase of this project two types of "treated" screen decks were experimented with to reduce the noise of this crank-arm shaker. The first was an ordinary steel punch plate with damping material experimentally applied to the bottom surface. The second deck was also steel punch plate, but with a polyurethane coating on the top surface. Neither deck provided satisfactory service due to difficulties with the bond between the damping and urethane materials, and the steel punch plate (see Volume 1 report, pp. 96-101).

During the course of this project, a new screen material, consisting of an abrasion resistant rubber top surface and a UHMWPE bottom layer, became available from B.F. Goodrich. Since the construction of the screen appeared to solve the bonding problems (the rubber and plastic are fused rather than bonded), the material was selected for evaluation on the primary shaker.

The test panel, which was actually two sections, was installed in February 1979. Each section was 48 in. wide by 60 in. long, 1 in. thick and had 6 in. dia. holes on 9 in. centers. The installation required 4 man-shifts (2 men - 2 shifts). This amount of time was necessary because of changes required in the mounting brackets; that is, the mounting brackets and supports had to be adjusted to suit the increased thickness of the screen. Once this change was made, however, replacement time was not expected to be much different than ordinary steel decks.

Although this test panel did not suffer from the delamination problems of the original "clad" decks, these panels did exhibit significant blinding (Fig. 11). The blinding, estimated by plant personnel to be 40-50%, was attributed to the thickness and resiliency of the panel. It should, of course, be noted that blinding potential is worse on these older crank-arm shakers

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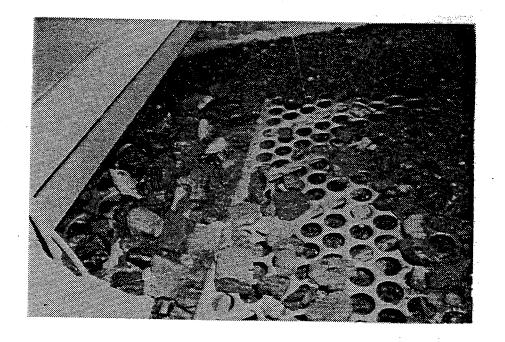


FIG. 11. PRIMARY SHAKER SCREEN (LEFT-HAND SCREEN PANEL IS GOODRICH MATERIAL, RIGHT-HAND PANEL IS STEEL).

and a screen deck's performance on these units is not necessarily indicative of their performance on the eccentric-weight screens. The test panels were left in place for the remainder of the monitoring period to evaluate the durability of the materials. Figure 12 shows the condition of the screens during a visit to the plant in July 1979. As can be seen in the figure the only significant wear occurred at two points on opposite sides of the holes. These points, which lie on a line across the screen (perpendicular to the flow), were the pivot points of the nearsized pieces which were lodged in the holes and rocked back-andforth with the action of the screen. As of the last plant visit, in June 1980, 16 months after installation, the panels were still in place. While the hole diameters had increased somewhat, no delamination was evident.

The original 1/2 in. Goodyear Armaplate impact pads that were installed between the screen sections were clearly worn by

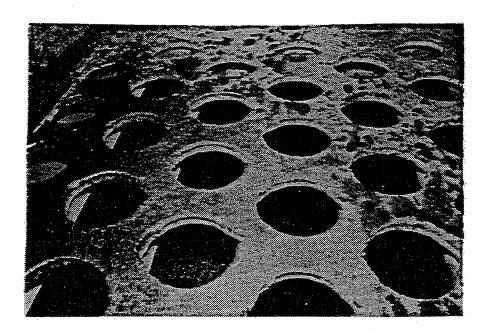


FIG. 12. GOODRICH MATERIAL ON PRIMARY SHAKER AS OF JULY 1979 (6 MONTHS AFTER INSTALLATION).

the June 1980 plant visit. Not only was this visible (see Fig. 13) but there was a distinctive sound generated by the impacts of the coal and rock as it dropped from one level on the shaker to the next lower level where the Armaplate was worn out. Although severely worn, it should be noted that these impact pads were in use for over three years.

Picking Table

The primary noise control treatments for the picking table were resilient impact pads installed near the operator's position to reduce the noise generated as the coal and rock dropped from the upper section to the lower section of the table. The origin-nal impact pad, 1/2 in. thick Goodyear Armaplate, was quite effective in reducing this impact noise. Unfortunately the 1/2 in. thickness was not sufficient for the volume and size of material on the table and was worn out after approximately 9

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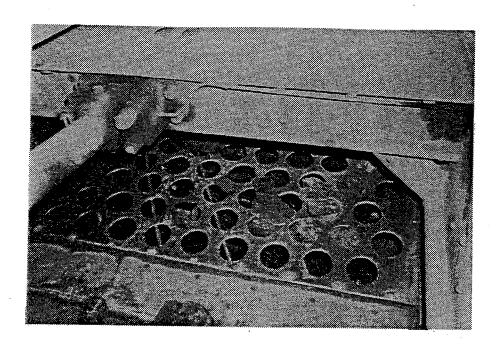


FIG. 13. WORN-OUT 1/2 IN. ARMAPLATE IMPACT PAD AT DISCHARGE OF PRIMARY SHAKER (AFTER 3 YEARS OF SERVICE).

months. The original pad was replaced with a 1-1/2 in. thick urethane pad which was at least as effective in reducing the impacts and provided significantly improved service life. Figures 14 and 15 show the pad shortly after installation (Nov. 1976) and after 1-1/2 years of service (July 1978). The pad eventually provided in excess of 2 years of service before requiring replacement.

The last material experimented with on this table was B.F. Goodrich's Linerite (see Fig. 16). This material was installed (with the UHMW plastic layer facing up) downstream of the above mentioned urethane impact pad to determine if this material would be effective in reducing the "rumble" from coal and rock moving across the table. Although the material provided a suitable table surface allowing proper material flow, it wore relatively quickly. It was installed in June 1979 and was worn out by December 1979.



FIG. 14. URETHANE IMPACT PAD INSTALLED ON PICKING TABLE (NOV. 1976).

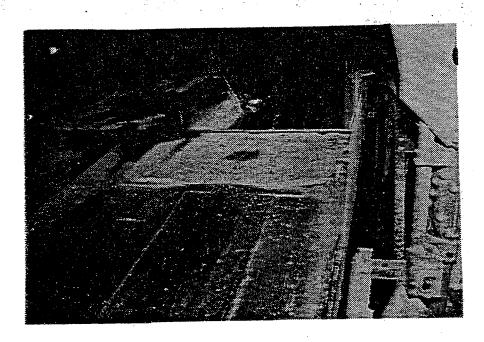


FIG. 15. URETHANE IMPACT PAD ON PICKING TABLE AFTER 1-1/2 YEARS OF SERVICE (JULY 1978).

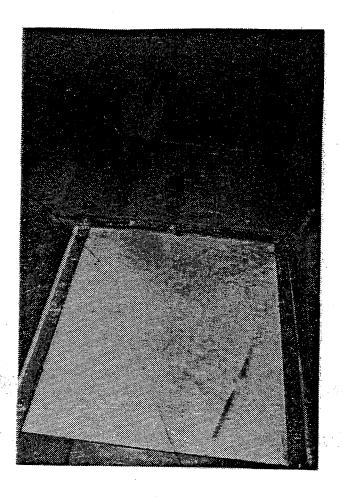


FIG. 16. B.F. GOODRICH LINERITE (UHMW SIDE UP) INSTALLED BELOW URETHANE IMPACT PAD ON PICKING TABLE.

McLanahan Rock Crusher

Two resilient pads were installed in the crusher infeed chute in 1976 to reduce the impact noise generated by large rocks falling into the open chute. The pads, which were 2-3/16 in. profiled Trelleborg rubber, were very effective in reducing these impacts. The profiled surface was selected to achieve a near 90° impact angle which is optimum for long service life. The pads turned out to be extremely durable, and were still quite serviceable after more than three years of operation (see Fig. 17).



FIG. 17. PROFILED TRELLEBORG IN INFEED TO MCLANAHAN CRUSHER (AFTER 3 YEARS OF SERVICE).

Secondary Shakers

During the first phase of this project several types of resilient screen decks were experimented with to reduce the noise from impacts on the original steel screen decks. The test decks included both all-rubber and all-urethane panels as well as rubber-clad-to-steel screen panels. Experience gained during this first phase of the project indicated that the relatively thick, all-rubber or urethane decks were not suitable for use on these low-speed, crank-arm shakers due to excessive blinding. The rubber-clad-to-steel test deck, on the other hand, performed reasonably well from a blinding point of view. Unfortunately the service life of the rubber did not exceed that of the original steel decks sufficiently to balance the higher initial cost of the clad decks. In addition to the screening noise, the open discharge chutes from the secondary shakers were also a major noise problem on this equipment. Although rubber chute liners

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ed the were experimented with during the first phase, the high volume of flow (which also results in significant coal-on-coal impact noise) resulted in a relatively high wear rate. As a result, covering the open tops of the chutes would be a much more cost-effective treatment.

Loaded-vinyl curtains were also installed around the secondary screens to reduce the noise radiated by these units to the washbox. The original curtain panels facing the washbox were replaced with clean vinyl panels to allow a visual check of the secondary discharges without opening the curtains (see Fig. 18). As of June 1980 (almost four years after the initial installation) the main panels around the secondaries were still in good condition. There were no noticeable tears around the grommets from which the curtains were hung; the sewn-on Velcro fasteners were still serviceable; and the curtains could still be opened



FIG. 18. CLEAR VINYL CURTAIN PANELS AT DISCHARGE OF SECONDARY SHAKERS.

and closed without difficulty. The clear vinyl panels, however, did not provide the desired visual access over the long-term due to a buildup of dirt. Plant personnel also reported that they had a tendency to stiffen during cold weather, making them difficult to open.

For future curtain installations it is recommended that the use of a 12 in. overlap and double rows of Velcro fastening strips at each openable seam would make the system more convenient and ensure a positive seal even when not closed carefully.

McNally-Baum Coal Jigs

Four types of noise control treatments were installed on the McNally-Baum coal jigs during the first phase of this project:

(1) resilient impact pads, (2) chute liners, (3) covers over open elevators and chutes, and (4) mufflers for the air blowers.

The resilient impact pads included both profiled rubber impact pads for the vertical chute walls at the discharge of the jig elevators, and flat urethane impact pads at the bottom of the refuse box (which feeds the refuse chutes). In both cases the impact pads outlasted the original steel chute work. In the case of the profiled rubber pads (which were similar to those installed at the infeed to the McLanahan crusher), wear was just becoming evident after two years of service (see Fig. 19). The original 1/2 in. solid steel plate was reported, by plant personnel, to have a service life of approximately 6 months. Even though the 1-1/2 in. flat urethane pad was worn through in 19 months this was still more than twice as long as the 9 months for original steel plate which was used to line the bottom of the feed box.

Two types of chute liners were installed in the refuse chutes during this program. The first material was 1/2 in. thic UHMWPE plastic chute lining. This material was worn out within

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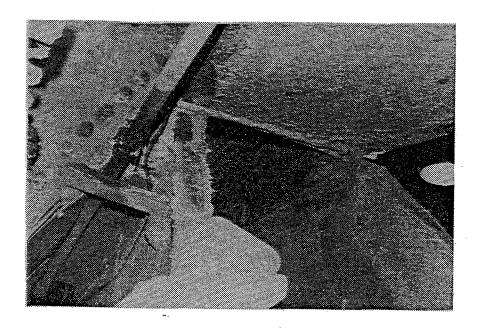


FIG. 19. PROFILED TRELLEBORG IMPACT PADS IN DISCHARGE OF JIG ELEVATORS (AFTER 2 YEARS OF SERVICE).

2-1/2 months of the initial installation. This is in contrast to the relatively long service life exhibited by the material in other areas of the plant, and is attributed to the tumbling nature of the flow in this application. The plastic chute liner was replaced with 1/2 in. ceramic tiles. These tiles were installed in February and September 1976 (for the No. 2 and No. 1 chutes, respectively) and while they did exhibit some cracking (Fig. 20), they were still serviceable and in use as of June 1980 (Fig. 21). The cracking is also attributed to the impacts resulting from the tumbling or bouncing of coarse refuse in the chutes.

In general, the covers over the jig elevators and chutes were effective and durable. The covers were not, however, consistently replaced after maintenance and inspection as can be seen in Fig. 22.

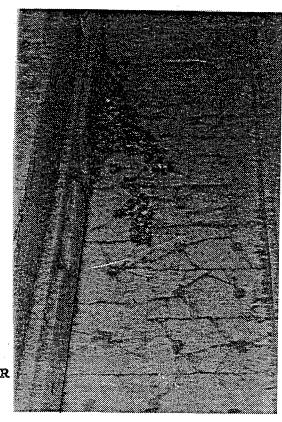


FIG. 20. CERAMIC TILE CHUTE LINER IN NO. 2 JIG DISCHARGE CHUTE (NOTE CRACKING OF TILES).



FIG. 21. CERAMIC TILE CHUTE LINER IN NO. 2 JIG REFUSE CHUTE AFTER MORE THAN 3 YEARS OF SERVICE.

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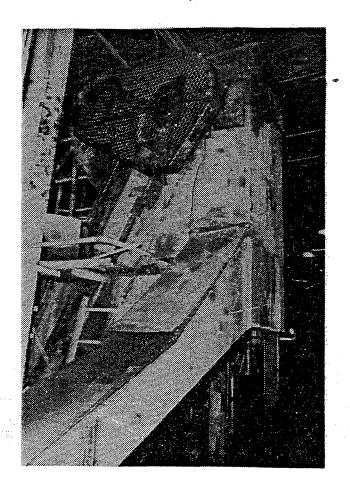


FIG. 22. REFUSE CHUTE ON NO. 2 JIG ELEVATOR.

Plant personnel reported no problems with the jig blower mufflers during the course of this project.

Middling Screens

The primary noise control treatment for these screens was a loaded-vinyl curtain installed around both screens. The original set of curtains were lined with sound absorbing foam on one side and were fitted with clear vinyl windows and Velcro fasteners at the seams. While these curtains were very effective in reducing the noise from these units, the sound absorbing foam became clogged with water and coal dust making them difficult to open.

These curtains were replaced with smooth loaded-vinyl curtain: similar to those used on the secondary screens (including a civinyl panel at the screen discharge). As was the case for the secondary screen installation, the plain loaded-vinyl curtains performed satisfactorily, but the clear panel became obscured with dirt (see Figs. 23 and 24) and stiff in the cold weather.

Clean Coal Desanding Shakers

Two materials were evaluated in this area: UHMW plastic chute liners for the discharges and loaded-vinyl curtains to separate the screens from the main aisle.

The 1/2 in. thick UHMW plastic was originally installed j both the discharge chutes and the receiving hoppers in Septemi 1976. After 5 months of service, the plastic in the receiving hoppers began to exhibit worn patches and was considered worn after 14 months. This experience was similar to that for the refuse chutes, again indicating that the UHMW plastic was not suitable for impact-type flows. The material flow at the scredischarges, on the other hand, is relatively smooth and unifor and in this application the plastic chute liner proved to be a durable (Fig. 25). As of June 1980, almost 4 years after the initial installation, the plant reported that only the tail pronounce of the placed.

The smooth loaded-vinyl curtains were installed in Septer 1976 and, as can be seen in Fig. 26, were still in good condition as of June 1980.

Ripl-Flo Screens

The noise control treatments for the Ripl-Flo* screens of sisted of loaded-vinyl curtains to separate the feed conveyor from the main aisle, urethane-clad-to-steel screen decks and rubber liners for the discharge chutes.

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FIG. 23. CLEAR VINYL CURTAIN AT DISCHARGE OF MIDDLINGS SCREENS (JULY 1978).

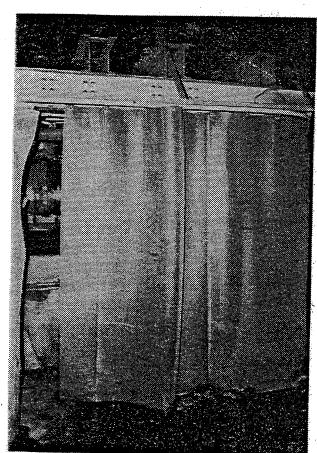


FIG. 24. DIRT BUILDUP ON CLEAR VINYL CURTAINS AT DISCHARGE OF MIDDLING SCREENS (JUNE 1980).

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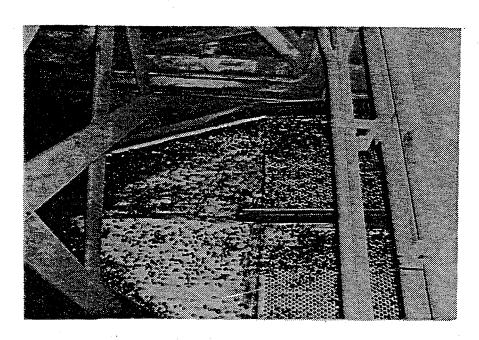


FIG. 25. UHMW IN CLEAN COAL DESANDING SCREENS AFTER ALMOST 4 YEARS OF SERVICE (JUNE 1980).

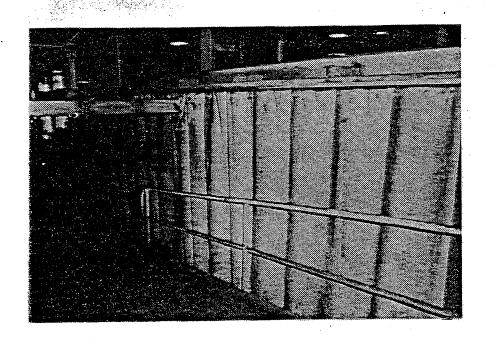


FIG. 26. LOADED-VINYL CURTAINS AROUND CLEAN COAL DESANDING SHAKERS AFTER ALMOST 4 YEARS OF SERVICE (JUNE 1980).

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The curtains used around the feed conveyor were the smooth loaded-vinyl type with Velcro fasteners at the seams, similar to those used in other areas of the plant. The curtains were installed in August 1976 and were still functioning and in good condition as of June 1980.

The resilient screen decks evaluated in this area consisted of a 1/4 in. thick Tuffgard-brand polyurethane top surface coldbonded to a 3/16 in. punch plate, and had 1-1/8 in. hexagonal holes. After approximately 7 months of service the urethane layer on one of the vibrators had completely separated from the steel backing (see Fig. 27). This separation was judged "premature" since the elastomer, although separated from the steel, did not exhibit significant wear. This indicated that the elastomer-clad screen deck life would have been significantly longer if it weren't for this apparent failure of the bond between the urethane and the steel.

Since this problem was not previously reported in the literature, a separate study was undertaken to investigate whether the conditions present in the Georgetown Plant were uniquely unsuitable for these screen decks or if the problem was inherent in some of the products. As part of this study, several types of elastomer-clad screen decks from two screen perforating companies were installed in four different coal preparation plants for further evaluation. The details of this study are discussed in Sec. 3 of this report.

The discharge chutes for four of the Ripl-Flo* screens (Nos. 3, 4, 5, and 6) were lined with rubber between December 1976 and January 1977. The materials proved to be quite durable with no reported problems other than some difficulty in one of the chutes with coal pushing between the rubber layer and the steel chute wall (see Fig. 28). This can be minimized by more careful orientation and protection of the seams during fabrication.

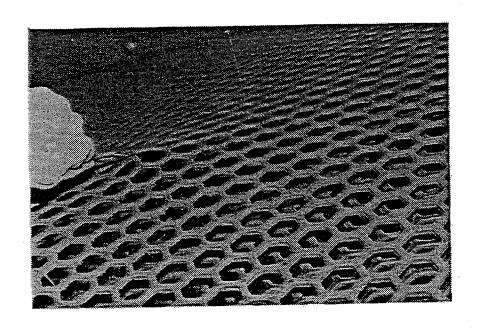


FIG. 27. DELAMINATION OF URETHANE LAYER ON RIPL-FLO* SCREENS.

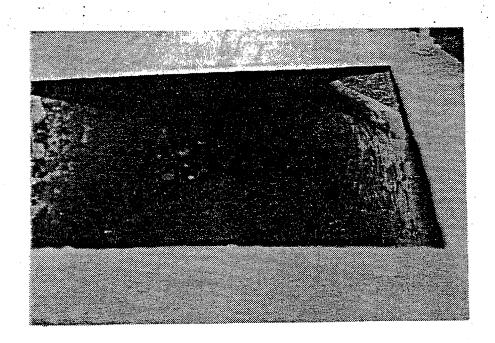


FIG. 28. RUBBER LINER IN RIPL-FLO® DISCHARGE CHUTE (NOTE BULG)
PRODUCED BY COAL PUSHING UNDER RUBBER LAYER - UPPER
RIGHT-HAND CORNER OF PHOTO).

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Gundlach Coal Crushers

The primary noise control treatment for this equipment was a curtain between the crushers and the aisle. The smooth loaded-vinyl curtain material was similar to that used elsewhere in the plant except that the Velcro fastener strips were originally glued rather than sewn onto the curtains. After three months the Velcro strips began to peel off the curtains and were in need of significant repair after approximately 6 months. In view of the durability of the sewn-on Velcro fasteners in other installations in the plant (some exceeding 4 years), it is recommended that all Velcro fasteners used in these applications should be sewn rather than glued to the curtain.

Reinveld Dryers and Wemco Dryers

Curtains were used around both the Reinveld and Wemco dryers. In both installations the curtains (loaded-vinyl with sewn-on Velcro fasteners) proved to be durable as well as effective. The curtains were installed around the Wemco dryers in April 1975 and the Reinveld dryers in November 1976. As of June 1980 both installations were functioning and in good condition. Figure 29 shows the curtains around the Reinveld dryers. The only repairs reported by the plant during this period were replacement of several of the stationary panels (behind the end dryer) which had become torn. These panels were replaced with fixed steel panels in 1979 (Fig. 30).

Classifying Shakers

Two types of treatments were installed on the classifying shaker system: a resilient impact pad at the infeed chute, and resilient decking on the screen itself. The impact pad was 2-3/16 in. profiled Trelleborg and provided approximately 2 years of effective service. The rubber-clad screen decks, on the other

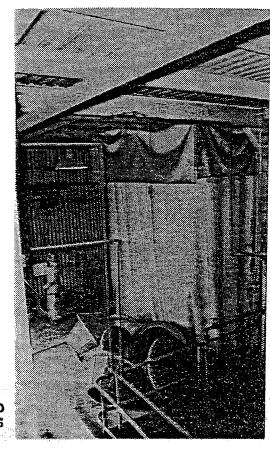


FIG. 29. CURTAINS AROUND REINVELD DRYERS AFTER 3-1/2 YEARS OF SERVICE.

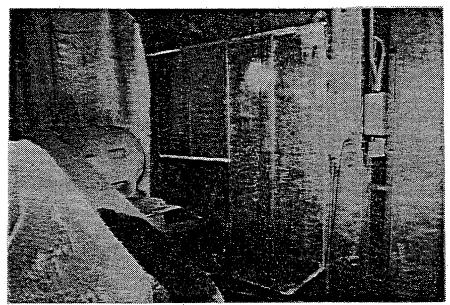


FIG. 30. ACOUSTICAL PANELS INSTALLED BEHIND END REINVELD DRYET TO REPLACE REAR CURTAIN PANELS (SEE TEXT).

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hand, developed blinding problems. Although the blinding problem was significant, no changes were made because this screen's use diminished due to changes in plant feed and market considerations.

2.2.2 Acoustic evaluation

As part of the long-term evaluation, sound level data were taken at various times during the monitoring period to document changes in plant sound levels. Ordinarily, this type of data could be used as a gauge or measure of the condition and long-term effectiveness of the noise control materials. In this case, however, this correlation is obscured by changes which have taken place during the monitoring period, in both plant operation and equipment.

At the beginning of this project, the majority of the runof-mine plant feed was obtained from underground mines which used continuous mining machines. Toward the end of the monitoring period the plant feed came predominantly from surface coal mines using loading shovels. As a result, the plant feed contained significantly more large material (over 1-1/2 in.) toward the end of the project. The net effect of this additional large material was an increase in the sound levels in the upper floors of Building A (where the coarse material is separated from the fine sizes) and around the jigs (where the coarse material is cleaned). The second operational change was that, during the final visit (June 1980), the plant feed had been increased from the orignal 1650 TPH to approximately 1800 TPH. This change, although small, would also tend to increase the sound levels in the plant.

Several major equipment changes were also made during the monitoring period. The first was the installation of a fine coal cleaning circuit. This equipment included froth floatation cells, a thermal dryer, a Derrick screen, vacuum disc filters, and vacuum pump system. Of this equipment the vacuum pumps are

expected to have the greatest impact on plant sound levels, particularly in the shop area on the ground floor of Building B. The second major change was the phasing out of the rail car shaker used to unload the rail cars carrying raw coal to the plant. This change (which resulted from the shift to trucked-in, surface-mined coal) eliminated one of the major noise problems at the plant.

Table 3 summarizes the results of the sound level data taken during this project. As can be seen in this table, the sound levels around the primary shaker and picking table areas generally fall between those measured prior to treatment and those measured after the initial treatment. The increase in sound levels during the final visit over those measured just after treatment in 1977, alongside the primary shaker, is due in part to the previously mentioned increase in large material passing over the screen. As mentioned in Sec. 2.2.1 the impact of the large material dropping from one level to the next was also audible due to wear of the 1/2 in. Armaplate impact pads between the screens. Since the effect of the worn Armaplate strips on the primary shaker has a small effect on the picking table operator's position and the impact pad at this position was in good condition during the final measurements, the increase in sound levels at the picking table over the 1977 data is primarily attributed to the previously mentioned operational changes. Figure 31 shows the sound pressure level spectrum at the picking table operator's position (A3) measured in 1980.

At the McLanahan rock crusher, the increase in sound level over the 1977 levels is also attributed to the change in plant feed, since the original noise control treatments (impact pads) were still functioning and in good condition.

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TABLE 3. SUMMARY OF A-WEIGHTED SOUND LEVELS AT STANDARD MEASURE-MENT POSITIONS.

Measurement Position	Associated Equipment	Measured Sound Levels, dBA				
		Before Treatment	After Treatment 6/23/77	As of 4/19/78	As of 7/20/78	As of 6/4/80
A ₁	Seit Drives	92	90 - 921	90 - 92	92 - 93	91 - 92
A ₂	Frimery Shaker	94	911	93	93	92 - 94
A3	Picking Table	94.	90 - 92	91 - 963	93 - 94	93 - 94
٨,	Boney Coal Crusher	93	91	92	94	92 - 94
B ₁	HeLanshan Rock Crusher	93 - 100	91 - 92	92	94 - 95	93 - 95
B ₂		92	933	-	-	-
c,		92	955	-	_	_
D ₁	Secondary Sizing Screens	96	-	1007	1007	100
D ₂		95 ~ 97	-	94 - 95	95	96
D ₃		97	93	94	94 - 95	96
z ₁	McNally-Baum Jigs	95	92 - 93	94	94 - 95	94
E ₂		97	91 - 93	92	93 - 94	93 ~ 94
E3		94 ~ 95	91	91 - 92	92	92 - 93
F ₁	Middling Vibrators	96	92	92	93	92 - 93
F ₂	į.	95	93 - 94	94	-	94.
F 3	1	94 - 97	92	92	93	93 - 94
G,	Clean-Coal Desanding Shakers	96 - 97	93	93	94 - 95	94
G ₂		96	95	96	97 + 98	97 - 98
H,	Ripl-Flo Screen Feed Conveyor	95	92 - 93	93	93	9.3
H ₂		94	91	92	93	92
H 3	Dryer Feed Conveyor	93	-	-	-	-
ı	Grundlach Crushers	96	90	91 - 92	91 - 92	99.8
I ₂		-	-	93	-	954
J	Ripl-Flo Screens	101	-	-	96	-
1,		100	-	-	92 - 93	-
K,	Vacuum Pump	95	-	91	92 - 93	94
L ₁	Refuse Desending Shaker	97	95	95	-	-
Mı	Reinveld Dryers	97 - 101	89 - 90	89	92	91
M ₂		99 - 103	91 - 92	91	93 - 94	92
N ₁	Jig Blowers	99	92 - 93	90	92	85
P ₁ ·	Wenco Dryers	95	-	-	-	-
P ₂	,	96	-	-	-	-
P,		96	90	86.4	-	90
q,	Head End Crushed Coal Beiz	100	91 - 94	95	93	90
Q ₂	Classifying Shakers	102	96 ~ 97	-	-	-
Q ₃		104	-	-	-	-
Q. j		103 - 104	-	-	-	_
R ₁	Jig Feeder	96	96*	94	-	-
s,	Rail Car Unloader (Shakeout)	111 - 113	-	-	-	-
τ,	Sytron Feeders	-	_	_	_	_

Resilient screen decks since removed.

²Apparent change in crusher action.

Additional curtain beffles at ceiling planned, 3 dB more reduction possible.

[&]quot;No specific treatments in this area.

³⁹⁶ dBA measured in afternoon when processing large quantities of surface coal.

Not running at full capacity.

⁷Measured while processing surface coal.

^{*}Curtains removed for repair.

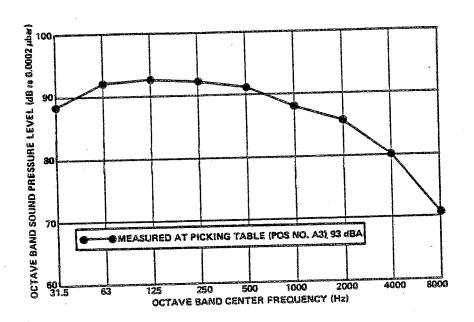


FIG. 31. SOUND PRESSURE LEVELS MEASURED AT PICKING TABLE OPERATOR'S POSITION.

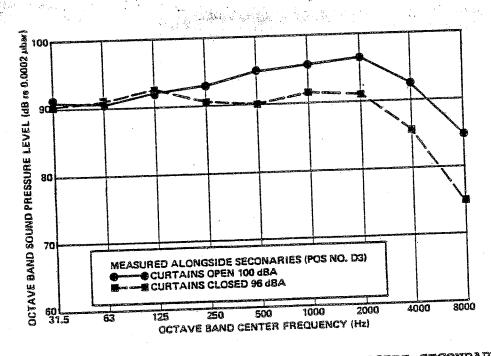


FIG. 32. SOUND PRESSURE LEVELS MEASURED ALONGSIDE SECONDARY SCREENS.

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The increase in coarse material also affects the sound levels around the secondary shakers. The upper curve in Fig. 32 was measured at position D3 with the curtains around the screens open* to simulate the "before" condition. The A-weighted sound level for this test was 100 dBA or 3 dBA more than that measured at the beginning of the program. The difference between the upper and lower curves in Fig. 32 also illustrates that although the sound levels have increased somewhat due to changes in plant operation, the curtains are still providing close to the original 4-5 dB of noise reduction (almost 4 years after initial installation).

The sound levels at the washbox control panel (position E3), have increased approximately halfway from the low of 91 dBA in 1977. This is attributed partially to the increased amount of coarse material being cleaned, and partially to the maintenance of some of the noise control treatments such as the covers over the jig elevators and refuse chutes (see Sec. 2.2.1).

As can be seen in Table 3, the curtains around the middlings vibrators are still providing noise reduction close to what was originally obtained in 1977.

The sound levels measured at the clean coal desanding shakers again illustrate the effect of changes in plant operation. Prior to any treatments the sound levels alongside the shakers (position Gl) were 96-97 dBA. Figure 33 shows the sound levels measured at this position in 1980. The upper curve represents the spectrum measured with the curtains completely* open, and is 3 to 4 dBA higher than the original sound levels. This correlates well with the increases resulting from the processing

^{*}The curtains must be completely open to minimize any reflection (or sound build-up) from the curtain surfaces.

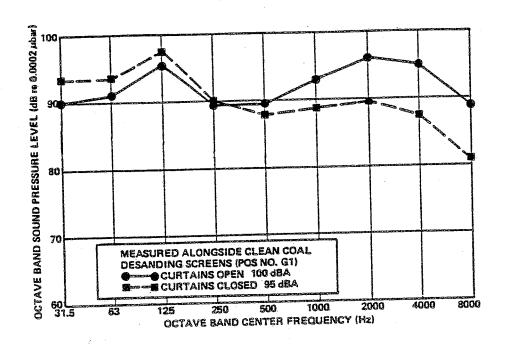


FIG. 33. SOUND PRESSURE LEVELS MEASURED ALONGSIDE CLEAN COAL DESANDING SCREENS.

of surface coal measured at other locations in the plant. The difference between the upper and lower curves in Fig. 33 indicates the current performance of the curtains, which is still comparable to that achieved in 1977.

The data measured around the Reinveld and Wemco dryers indicates that the curtains in these test areas are also providing most of their original noise reduction. This clearly demonstrates the long-term effectiveness of those treatments, particularly for the curtains around the Wemco dryers which were installed in 1975.

Although the Ripl-Flo* screens were not operating at full capacity during the final visit to the plant, it was possible to obtain "close-in" data at the discharge chutes to measure the effectiveness of the rubber chute liners. Figure 34 shows the spectra measured 6 in. from both lined and unlined discharge

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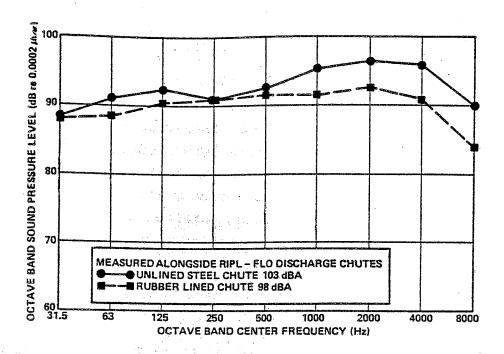


FIG. 34. SOUND PRESSURE LEVELS MEASURED 6 IN. FROM RIPL-FLOT DISCHARGE CHUTES.

chutes. As can be seen, the 1/2 in. rubber chute lining is still providing a 4-5 dBA reduction in the noise radiated by the chutes.

Since the vacuum pumps for the disc filters on the new fine coal circuits were not fully operational at the time of the final visit, it was not possible to fully assess their impact on the sound levels on the ground floor of Building B. It is anticiated, however, that this equipment has the capability of raising the sound level in this area (and, in particular, the main shop area) to above 90 dBA.

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3. SUPPLEMENTARY SCREEN DECK TESTS

3.1 Background and Purpose

Several types of "resilient" screen decks were tested during the first phase of this project to determine their noise reduction potential. The elastomeric top surface on these decks is intended to reduce screening noise, that is, the noise generated by the impacts of the coal and rock on the metal screen decks. Although the initial evaluation verified that such decks had the potential to reduce screen noise (particulary for older crank-arm shakers), the initial testing also revealed several problems: blinding and delamination. Blinding, or plugging of the screen openings by near-sized material, was primarily a problem for the thicker screen decks on the crank-arm shakers. While blinding did not appear to be a problem on the Ripl-Flo type screens, delamination of the resilient top surface from the steel punch plate (see Sec. 2.2.1) was a problem. Delamination was also evident, although to a smaller degree, on some of the rubberclad-to-steel decks installed on the other shakers. results were in contrast to the purported durability of these screens in similar service in other industries.

Since these problems were not previously reported, and prevented a full evaluation of the actual wear life of the elastomer top surface, supplementary resilient screen deck tests were undertaken. The primary purpose of these supplementary tests was to determine if the operational problems observed in the Georgetown Plant were inherent in the screen decks or the result of the specific operating conditions at the Georgetown Plant. These tests, therefore, were not conducted in the Georgetown Plant and concentrated on evaluating the operational performance of the decks rather than re-verifying noise reduction data obtained during the first phase.

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3.2 Project Organization

These supplementary screen deck tests were performed in conjunction with Hendrick Mfg. Co. and Laubenstein Mfg. Co., two of the largest screen manufacturers in the United States. Each company arranged for two cooperating coal preparation plants, provided the screen decks to be tested, and arranged for one of their representatives to supervise the installation and monitor the performance of the test decks.

At the outset, it was determined that each screen manufacturer would provide representative samples of the two most common types of elastomer-clad decks they were producing at the time. For Hendrick, these were a 48 durometer Gates SBR rubber vulcanized to the steel punch plate and a 40 durometer Linatex natural rubber cold-bonded to the steel base plate. Laubenstein's decks were manufactured from an 80 durometer Tuffgard polyurethane which was cast onto a steel punch plate and a 40 durometer Linatex natural rubber cold-bonded to a steel punch plate.

In addition to the clad screen decks, each manufacturer also provided ordinary steel punch plate screen decks which were to be used as a control group. Although it was originally intended that the cooperating plants would have three parallel screens to allow a direct comparison with the plain steel decks, it was only possible to obtain pairs of vibrators within each plant which were close enough (in flow volume) to allow a reasonable comparison. As a result, the program concentrated on testing the elastomer-clad screen decks.

The manufacturer's representatives were present during the installation of the test decks to ensure that they were installed correctly, and visited the plants periodically during the monitoring period. During these visits, production data were obtained and the condition of the decks was documented using data forms developed specifically for these tests.

The results obtained at each of the four demonstration plants will be discussed individually in the following sections. The test screens in the first two plants (A and B) were provided by Hendrick and those in the second two plants (C and D) were provided by Laubenstein.

3.3 Plant A

3.3.1 Screening equipment

Two parallel Allis-Chalmers Ripl-Flo raw coal screens were selected to test the screen decks in this plant. The 7 ft × 20 ft double-deck vibrators are each fed approximately 275 TPH of 5 × 0 raw coal. For record keeping purposes these screens were designated Tl and T2. Each screen was originally fitted with two steel punch plates on the feed end and three woven wire panels on the discharge end of the top deck. The punch plates were 1/4 in. steel with 7/8 in. round holes and a 55% open area. The woven wire panels had 3/4 in. square openings and a 61% open area. The plant reported that the original punch plates on the feed end required replacement approximately every 6 months. Figure 35 shows the general arrangement of the raw coal; screening area.

3.3.2 Test screen decks

The screen decks tested in this plant (Fig. 36) were fabricated from either the 48 durometer SBR rubber vulcanized to a steel punch plate or the 40 durometer natural rubber cold-bonded to a steel punch plate. Although the screen deck materials were determined prior to the selection of the plant, the dimensions must be based on the specific needs of the plant and were therefore specified by the manufacturer after discussion with plant personnel. For both materials the elastomer top layer was 3/8 in. thick, the steel was 3/16 in. thick and the holes were 7/8 in. diameter on 1-3/8 in. staggered centers. The net open area

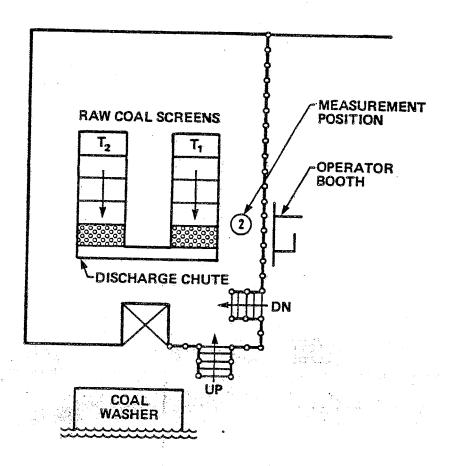


FIG. 35. RAW COAL SCREENING AREA OF PLANT A.

for these decks (37%) was significantly lower than the original steel screens. The manufacturer supplied six panels of each type (five plus one spare).

3.3.3 Test results

The test decks were installed on October 25, 1978. The ten elastomer-clad screen panels (5 screen panels per vibrator) were installed during one midnight shift. The only problem encountered during the installation was the tight fit of the clamping bars due to the increased thickness of the elastomer-clad decks (as compared to the original screen decks). To ensure that the

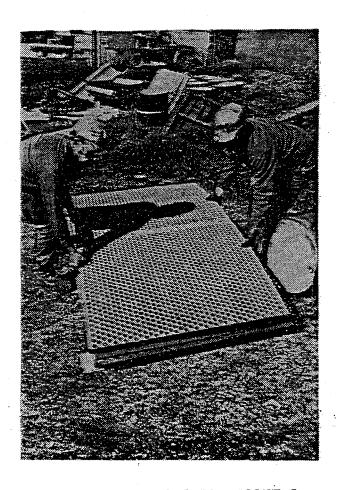


FIG. 36. RUBBER-CLAD SCREEN DECKS FOR PLANT A.

flow of raw coal over both materials was equal, the screen deck materials were alternated on each screen (Fig. 37). That is, the 40 durometer rubber-clad feed panel on screen Tl was followed by a 48 durometer rubber-clad panel, which was followed by another 40 durometer panel, etc. The order of the panels on screen T2 was reversed (starting with a 48 durometer rubber-clad panel) to normalize the flow of raw coal over the two materials. Originally, no impact pads were installed on either feed panel.

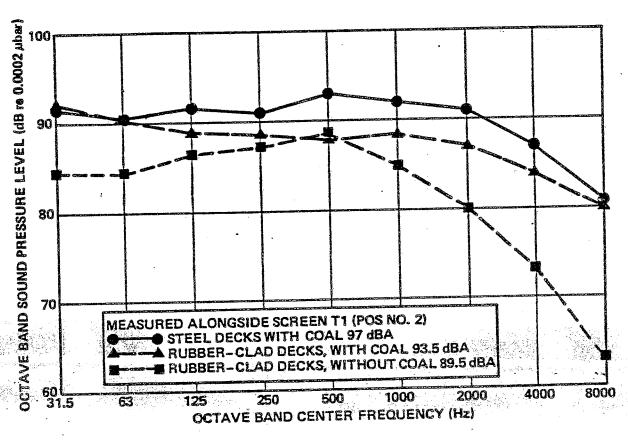
An analysis of the sound level data taken prior to and just after the installation of the elastomer-clad screen decks indicates that these decks reduced the sound levels in the screening area by 2-1/2 to 5 dBA, with 3 - 4 dBA being typical.



FIG. 37. INSTALLATION OF RUBBER-CLAD SCREEN DECKS IN PLANT A.

Figure 38 shows the sound spectra measured approximately 5 ft from the side of screen Tl (Position No. 2 in Fig. 35) before and after treatment. As can be seen in the figure, the A-weighted sound level was reduced by 3-1/2 dBA. This noise reduction is quite good considering that the infeed and outfeed chutes, the lower deck, and the drive mechanism remained untreated. The level of drive mechanism noise is illustrated by the lowest curve in Fig. 38.

From an operational point of view, two problems developed with the rubber-clad screen decks shortly after installation. The first problem was that the feed panels on both screens began



SOUND PRESSURE LEVELS MEASURED ALONGSIDE RAW COAL FIG. 38. SCREENS IN PLANT A.

to wear rapidly at the point where the feed impacted the deck. To alleviate this problem, a 12 in. × 12 in. perforated steel plate was temporarily bolted onto the feed panel over the impact point. Over the long term this would best be solved by a resilient impact pad, a redesign of the feed of raw coal onto the deck, or a combination of the two. The second problem was that the decreased open area of the elastomer-clad decks resulted in too much fine material flowing over the deck and entering the coarse coal section of the washer (which was fed by the raw coal screens). Since it was not possible to increase the screening area or adjust the capacities of the washing equipment, it was necessary to replace the last two elastomer-clad panels with woven wire panels. 56

In terms of durability, neither the vulcanized 48 durometer nor the cold-bonded 40 durometer screen decks provided the anticipated service life. In addition to the wear at the impact point on the infeed panels observed shortly after installation, significant wear was evident on the second panel on each screen during the second visit to the plant (19 January 1979) and on the third panel by the fourth visit (6 March 1979). This is summarized in Fig. 39 which plots the cumulative tonnage versus time. The wear observed during these visits was described as a combination of wear and delamination similar to that observed at the Georgetown Plant.

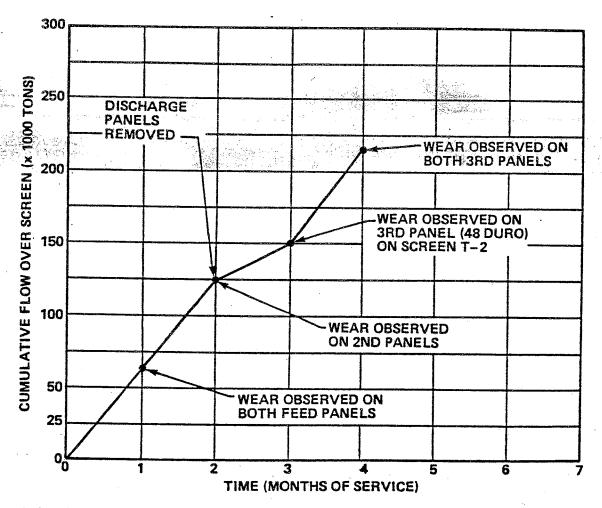


FIG. 39. SERVICE HISTORY OF TEST DECKS IN PLANT A.

3.3.4 Comment

The screen deck tests in Plant A indicated that while the elastomer-clad screen decks did provide meaningful noise reduction, they did exhibit several operational and durability problems. Some of the problems, such as the wear at the infeed panel and the open area, have as much to do with specific design of the installation as the capabilities of the screen decks. In this case it appears that the original hole diameter specification was too small for this operation. The wear patterns exhibited by these screens, however, leave open the question of overall durability. It may also be pointed out that, within the resolution provided by this field test, no distinct differences were discerned between the two screen deck materials.

3.4 Plant B

3.4.1 Screening equipment

The screening area selected in Plant B contained four single deck Hewitt-Robins Vibrex* (Model V-11) screens. The 3 × 0 raw coal entering the plant (700 TPH) is divided equally between two parallel circuits (A and B). Each circuit uses two of the 7 ft × 16 ft raw coal screens. The two screens selected for these tests are labeled B1 and B2 in Fig. 40. Each screen was originally fitted with a woven wire deck that had 5/16 in. openings and a 48% open area. The plant reported that the woven wire decks typically required replacement or maintenance every 6 months.

3.4.2 Test screen decks

While the screen decks tested in this plant were the same materials as those tested in Plant A, the dimensions were altered to suit the needs of this plant. Since the average size of the raw coal was smaller than for Plant A, the thickness of the elastomer layer was specified to be 3/16 in. rather than the 3/8 in.

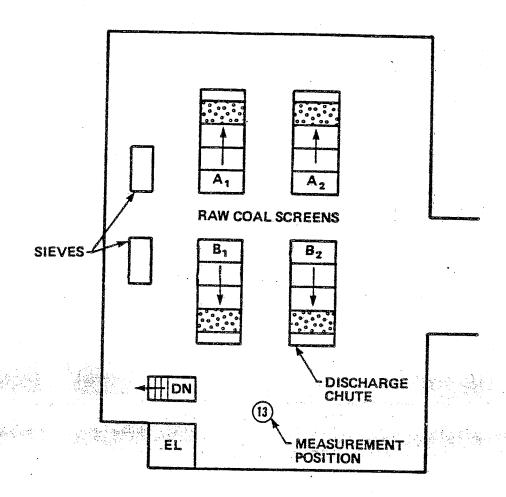


FIG. 40. RAW COAL SCREENING AREA OF PLANT B.

used in Plant A. The holes were 3/8 in. (round) on 5/8 in. staggered centers resulting in an open area of 33%. The manufacturer supplied 5 screen panels of each type (4 for each screen plus one spare).

3.4.3 Test results

The test decks were installed during the midnight shift on October 26, 1978. Since the Hewitt-Robins screens used wedge pins instead of bolts to secure the clamping bars (see Fig. 41), the installation time was substantially reduced. The total installation time for all 8 screen panels was 3 hours, which was

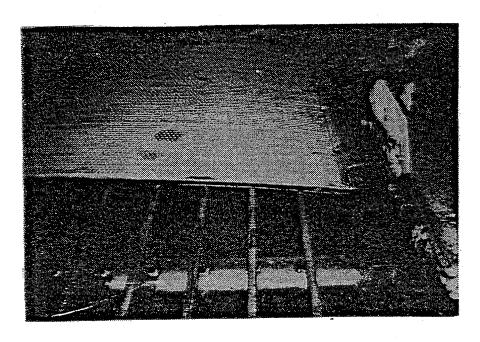


FIG. 41. CLAMPING BAR ARRANGEMENT ON TEST SCREENS IN PLANT B.

less than half of that required to replace the ten screen panels at Plant B. No problems were encountered during the installation.

The order of the test panels was again alternated, as was done in Plant A, to normalize the flow over each material. For screen Bl, the 40 durometer feed panel was followed by a 48 durometer panel which in turn was followed by another 40 durometer panel, etc. The order of the panels on screen B2 was reversed starting with a 48 durometer feed panel.

Although the decks were not originally supplied with impact pads, solid rubber impact pads were installed on the feed panels of both screens during the first month of service.

It was not possible, due to scheduling difficulties at the plant, to obtain a direct comparison of the full-operation sound levels on the screening floor before and after the installation of the screen decks. However, an estimate of the effect of elastomer-clad decks can be obtained from Fig. 42. This figure

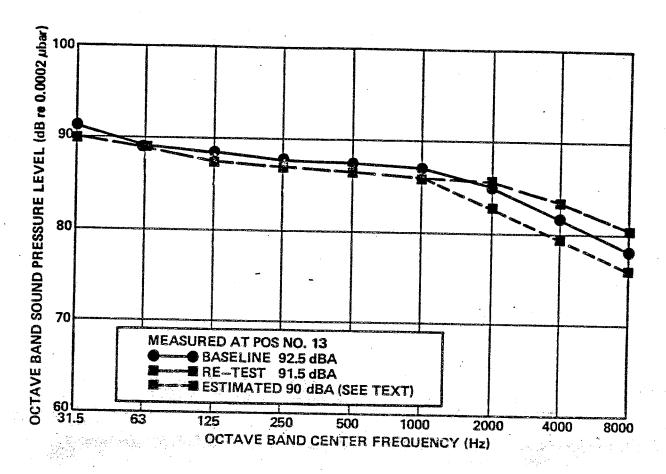


FIG. 42. SOUND PRESSURE LEVELS MEASURED ON RAW COAL SCREENING FLOOR OF PLANT B.

shows the sound spectra at Position No. 13 (see Fig. 40) under various conditions. The spectrum labeled "Baseline" (92.5 dBA) represents the sound levels measured under full operation with the original woven wire decks. The spectrum labeled "Re-Test" (91.5 dBA) represents the sound levels measured at a later date with three elastomer-clad panels in place on each screen (see discussion below regarding the re-test in this plant).

The difference between these curves, which would ordinarily represent the noise reduction resulting from the elastomer-clad decks, underestimates this noise reduction for two reasons. The first is that the sound levels on the untreated side (A) of the

screening floor were higher during the re-test than during baseline tests; and the second is that only three of the four panels
were elastomer-clad. The first reason indicates that some basic
change took place since the original measurements were made.
This change could be due to increased tonnage, changes in water
spray nozzles, changes in water pressure or some other unknown
factor. Nevertheless, this change results in the re-test spectrum being higher than expected (in fact, they are even higher
than the baseline levels which is in contrast to previous experience with elastomer-clad decks). It is possible to correct for
this by reducing the high frequency portion of the re-test spectrum by an amount equal to the net change observed near the
untreated screens. This was done and the corrected spectrum,
labeled "Estimated," is also shown in Fig. 42.

Since it is not as straightforward to correct for the second reason (only three clad screen decks) the difference between the "Baseline" and "Estimated" spectra (i.e., 2 dBA) should be considered the minimum noise reduction achieved. The maximum may be estimated by comparing the sound levels measured near the treated (B) screens with those near the untreated (A) screens. This difference is approximately 6 dBA. This 2 - 6 dBA range is similar to the 2-1/2 to 5 dBA range measured in Plant A.

From an operational point of view, the elastomer-clad decks performed significantly better in this plant than they did in plant A. The plant personnel reported no significant changes in cleaning efficiency or capacity during the course of the test, in spite of the fact that the test decks did have a smaller net open area.

In terms of overall durability, the test decks performed quite well for the first three months of operation. In the third and fourth months of service, evidence of deterioration began to be evident (particularly on the last two panels of screen Bl).

Figure 43 summarizes the monitoring of the test decks in Plant B. This deterioration was described by the manufacturer's representative as an apparent failure of the bond between the rubber layer and the steel punch plate (again, similar to the experience at the Georgetown Plant). The conclusion was verified during a visit to the plant in July 1979, 9 months after the installation. Figure 44 illustrates how the rubber layer, being held in the photo, had separated from the steel punch plate. This was considered a premature failure since the separated rubber layer was still relatively thick, indicating that if it hadn't separated it would have still been serviceable.

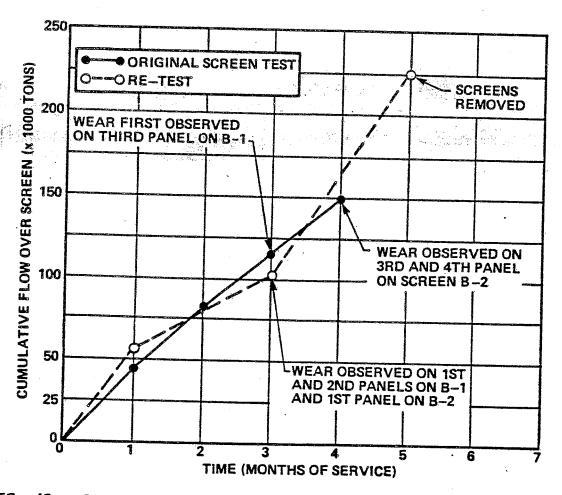


FIG. 43. SERVICE HISTORY OF TEST DECKS IN PLANT B.



FIG. 44. DELAMINATION OF RUBBER-CLAD SCREEN DECK IN PLANT B.

Because the deterioration of the screen decks appeared to be bonding related and more rapid than experience with similar screens in Plants C and D, additional tests were undertaken to determine the extent to which the composition of the steel punch plate affects the bond. For these additional tests, screen B2 was fitted with three elastomer-clad screen panels identical to the 40 durometer, cold-bonded decks evaluated previously, and screen B1 was fitted with three similar panels except that the punch plate was made of CORTEN steel.

The six test panels were installed on April 23, 1980. Since the test panels had the same basic dimensions (hole size, open area, etc.) as the original test decks, no screening problems were anticipated and none were observed. The first signs of wear became evident three months after installation. Although the difference between the wear on the two types of decks was small, the panels with the CORTEN backing exhibited somewhat more wear. The overall timing of the wear in either case, however, does not

appear to be markedly different than observed during the initial tests. This can be seen by comparing the observations in Fig. 43. While the timing of the wear resembled that observed during the initial tests, the wear patterns did not exhibit the same distinct evidence of delamination. In these tests, the wear appears to be due to abrasion and tearing (or cutting). This can be seen in Figs. 45 and 46 where the elastomer is worn thin and abraded in contrast to the previous tests where the elastomer separated from the steel before significant abrasive wear could take place.

3.4.4 Comments

The tests in Plant B corroborated the noise reduction figures observed in Plant B, and previously in the Georgetown Plant.

Although the test decks performed well from a screening efficiency point-of-view in this plant, the durability did not meet the expectations. The initial tests indicated that the durability problems were related, at least in part, to a failure of the bond between the elastomer and the steel punch plate. The second set of tests indicated that this problem, which was first observed in the Georgetown Plant, is not solely a function of the backing material and therefore requires further investigation.

3.5 Plant C

3.5.1 Screening equipment

Two of the four clean coal screens were selected for testing in Plant C. The screens, 8 ft \times 16 ft Allis-Chalmers Low-Heads, were each fed approximately 250 TPH of 6 \times 0 clean coal from the washer. The layout of the clean coal screening area is shown in Fig. 47. The screens were originally fitted with perforated plate screen decks. The original decks were 1/4 in. plate with

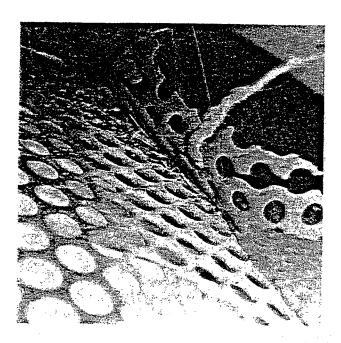


FIG. 45. TYPICAL ABRASIVE WEAR PATTERN OF ELASTOMER-CLAD SCREEN DECKS.

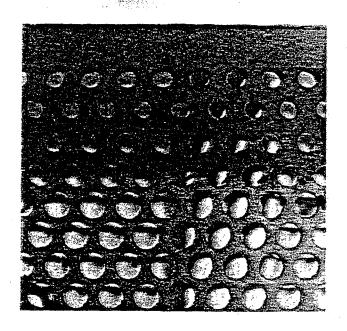


FIG. 46. TYPICAL ABRASIVE WEAR PATTERN ON ELASTOMER-CLAD SCREEN DECKS.

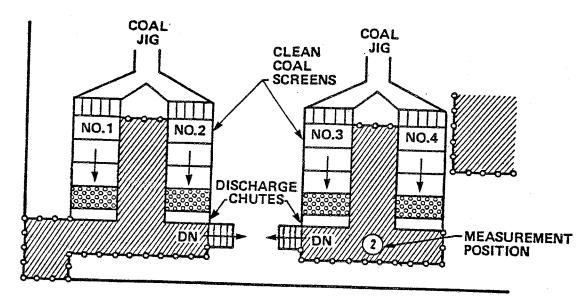


FIG. 47. CLEAN COAL SCREENING AREA OF PLANT C.

3/4 in. diameter holes on staggered centers. The open area of the original decks was approximately 50%, and the typical life of the original steel decks was reported to be 6 months.

3.5.2 Test screen decks

As was the case for Plants A and B, two types of elastomerclad screen decks were tested in this plant. The first type was a 40 durometer natural rubber cold-bonded to a 3/16 in. CORTEN steel punch plate. The 3/8 in. thick rubber top surface is the same material as that tested in Plants A and B. These decks had 1 in. round holes on 1-7/16 in. staggered centers and were approximately 40% open. The feed panel was originally fitted with an impact pad.

The second type of decking was an 80 durometer polyurethane which was cast onto a 3/16 in. CORTEN steel punch plate. The casting process allowed the urethane to completely encapsulate the steel backing. The thickness of the urethane top surface was 3/8 in. and the total thickness of the screen was 3/4 in. The holes for these decks were approximately the same as for the

rubber-clad decks, and an impact pad was also fitted to the feed panel (see Fig. 48).

3.5.3 Test results

The test decks were installed on March 30, 1979. The total installation time, including the removal of the existing steel decks, was one shift. No mounting modifications were required for either deck type. Because of the slight difference in deck thickness, it was not possible to alternate deck types on a single screen, as was done in Plants A and B. However, plant personnel indicated that the coal feed was quite evenly divided between the two screens. The rubber-clad panels were installed on screen No. 3 and the urethane-clad panels were installed on screen No. 4.

Figure 49 summarizes the sound level data measured between the screens (Position 2 in Fig. 47) before and after the installation of the elastomer-clad decks. As can be seen by comparing the steel and elastomer-clad spectra (with coal), there was only



FIG. 48. SOLID IMPACT PAD ON URETHANE-CLAD FEED PANEL IN PLANT C.

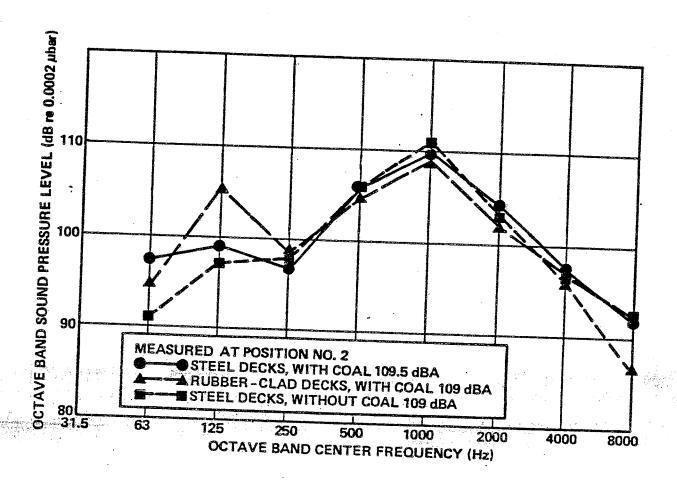


FIG. 49. SOUND PRESSURE LEVELS MEASURED IN CLEAN COAL SCREENING AREA OF PLANT C.

a slight change in the sound spectrum after the installation of the elastomer-clad decks. The reason for this small amount of noise reduction is evident by noting that the drive noise of these screens dominates the impact noise due to the coal flow. As a result, any reduction of the coal impact noise achieved by the installation of the elastomer-clad decks is masked by the drive noise which is not altered by the decks. It should also be noted that the drive noise of these screens is unusually high (109 dBA) and indicates that a mechanical problem may exist in the drive system.

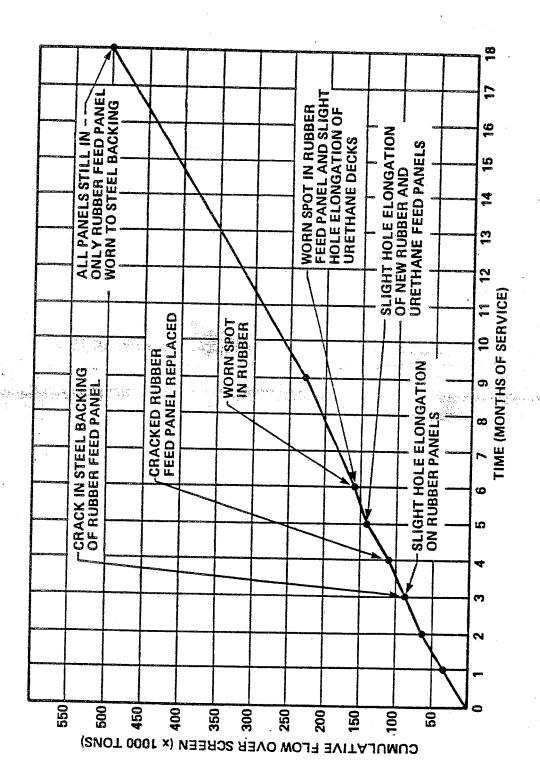
Over the course of the monitoring period, all of the test panels performed quite well. No significant blinding was observed, other than that resulting from the screen supports. In addition, the plant personnel found the screening ability to be quite acceptable.

With regard to overall durability, the screen decks also performed quite well. The results of the durability monitoring are summarized in Fig. 50. Since the test decks were still in relatively good condition after the initial six-month monitoring period, it was decided to extend the monitoring period. the tonnage estimates are only available for 18 months, the last visit by the manufacturer's representative took place 21 months after the initial installation. As of this visit, all of the test panels were still in place and most were judged to have significant service life remaining. The only panel exhibiting excessive wear was the second rubber-clad feed panel, where the rubber had worn through the steel backing just below the impact pad. The original rubber-clad feed panel was replaced after 3 months due to a crack in the steel backing. This was, however, judged to be a problem with the support mechanism rather than the panel itself. The remaining rubber-clad panels generally exhibited moderate wear, primarily an elongation of the holes, as of the last visit. The urethane-clad panels, on the other hand, proved to be exceptionally durable with only slight wear observed on any of the panels after 21 months.

Finally, no instances of large scale delamination of the elastomer-cladding was evident on any of the panels tested in this plant.

3.5.4 Comments

The test results in this plant were very encouraging. Both the rubber and urethane decks performed quite well from both



G. 50. SERVICE HISTORY OF TEST DECKS IN PLANT C.

operational and durability standpoints. The durability is illustrated by noting that most of the elastomer-clad panels (particularly the urethane panels) were in relatively good condition almost 2 years after installation, whereas the original steel decks were reported to need replacement after 6 months. Since the test decks were still in use at the end of the monitoring period, it was not possible to assess the final cost effectiveness. However, they had already outlasted the original decks by almost a factor of 4 and apparently had appreciable life remaining at the end of the monitoring period.

With respect to noise, the negligible amount of noise reduction measured in this installation was clearly due to the unusually noisy drive mechanisms rather than a lack of noise reduction capability of the elastomer-clad decks.

3.6 Plant D

3.6.1 Screen equipment

The two prewet screens were selected to test the elastomerclad screen decks in Plant D. The screens were 8 ft × 16 ft double-deck Allis-Chalmers Low Heads. Each screen was fed approximately 500 TPH of 3/8 in. × 6 in. raw coal. The original steel screen decks were 1/4 in. thick and had 1-3/8 in. hexagonal holes on staggered centers. As in the previous plants, the original steel decks were reported to last approximately 6 months. Figure 51 shows the general layout of the screening area.

3.6.2 Test screen decks

The screen deck materials tested in this plant were the same as those tested in Plant C. That is, 40 durometer rubber coldbonded to CORTEN steel and 80 durometer urethane cast on CORTEN steel. The rubber-clad panels consisted of a 3/8 in. thick rubber cladding and a 3/16 in. steel backing plate. The holes were

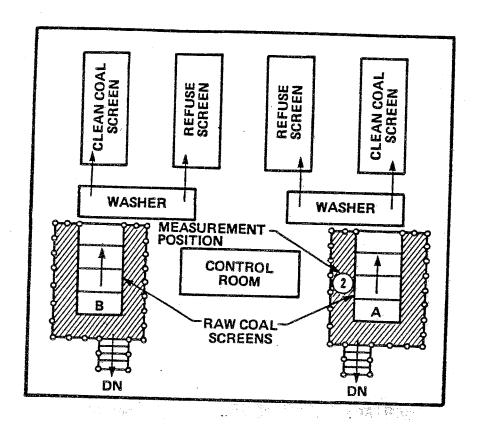


FIG. 51. SCREENING FLOOR OF PLANT D.

3/4 in. diameter on 1-3/16 in. staggered centers, resulting in an open area of roughly 40%.

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The urethane panels also had a 3/8 in. thick top layer and a 3/16 in. thick steel backing. However, since a thin urethane layer was also cast along the bottom, the total thickness of these panels was 5/8 in. thick rather than the 9/16 in. of the rubber-clad panels. In addition, while the original intention was to have the hole size be 3/4 in. in diameter (which was the case for the rubber-clad panels), the screen panels were actually produced with 5/8 in. diameter holes. The effect of this difference is discussed below under test results.

Finally, while the test decks were originally equipped with impact pads, as shown in Fig. 52, they were not used (see test results).

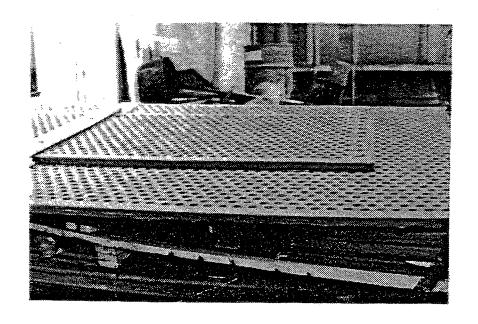


FIG. 52. PERFORATED IMPACT PAD ON URETHANE-CLAD FEED PANEL IN PLANT D (SEE TEXT).

3.6.3 Test results

The test decks were installed on March 24, 1979. Since the two types of decks again had different thicknesses, it was not possible to alternate the two materials on each screen, as was done in Plants A and B. The urethane-clad panels were installed on screen A in approximately 5 hours and the rubber-clad panels were installed on screen B in approximately 3 hours. No unusual problems were encountered during installation and it is not known why there was a difference in installation time between the two materials. Both installation times include removal of the old decks. Although both decks were originally supplied with impact pads on the feed panels, the pad on the rubber-clad deck was loose and was removed prior to installation. To permit a fair comparison of the materials, the impact pad on the urethane feed panel was also removed.

Figure 53 shows the sound spectra measured alongside screen A (position 2 in Fig. 51) before and after the installation of

From an operational standpoint, the only problem that developed during the testing was related to the hole size of the urethane panels. Because the actual hole size was 5/8 in. rather than the specified 3/4 in., the plant reported that too much undersized material was flowing over the decks. This problem was alleviated, however, by exchanging the urethane-clad feed panel with the spare urethane-clad panel from plant C (which had 7/8 in. diameter holes), and installing a 3 in. high dam across the screen to slow down the flow.

Figure 54 summarizes the results of the durability monitoring. As can be seen, the rubber-clad panels exhibited some hole elongation after 3 months of service and the rubber-clad feed panel exhibited significant wear. The rubber-clad feed panel was replaced after 3-1/2 months due to excessive wear (see Fig. 55). At the end of the initial 6 month period, the thickness of the rubber-clad panels was typically 75% of the original thickness. At the end of 9 months the rubber-clad panels were worn out and removed.

The urethane-clad panels, on the other hand, proved to be extremely durable. Figure 56 shows the urethane-clad feed panel after 3-1/2 months of service (taken at the same time as Fig. 55 for the rubber-clad panels). At the end of 6 months, only a slight hole elongation was evident on the urethane-clad panels. After 14 months of service, the two urethane-clad discharge panels were installed on the feed end of screen B (from which the rubber-clad panels were removed). The urethane-clad panels were eventually removed after 16 months because of cracking of the steel backing (rather than wear of the urethane top surface).

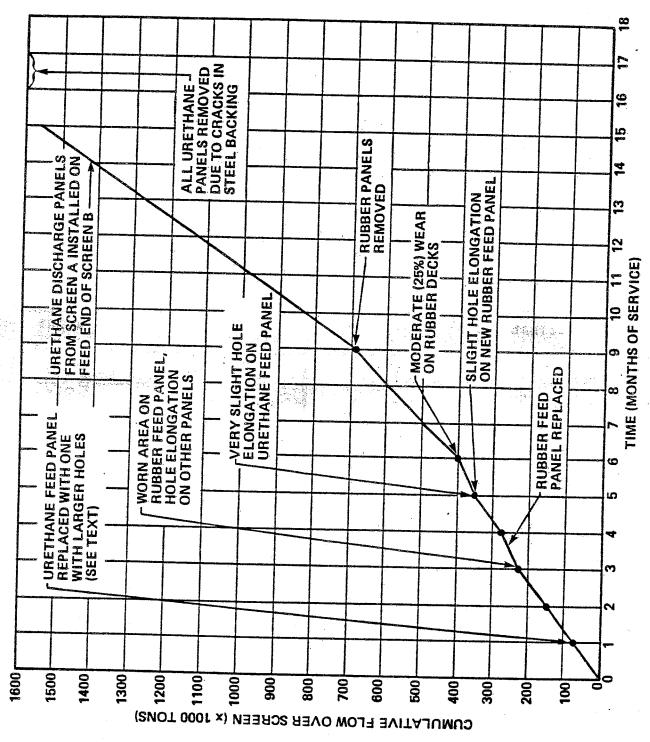


FIG. 54. SERVICE HISTORY OF TEST DECKS IN PLANT D.

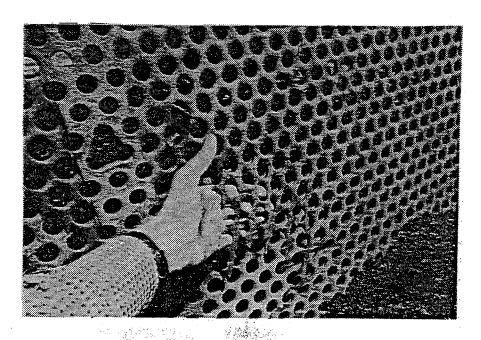


FIG. 55. RUBBER-CLAD FEED PANEL IN PLANT D AFTER 3-1/2 MONTHS OF SERVICE.

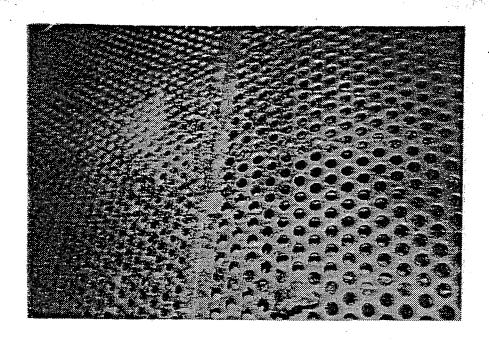


FIG. 56. URETHANE-CLAD FEED PANEL (RIGHT-HAND SIDE OF PHOTO) AFTER 3-1/2 MONTHS OF SERVICE.

3.6.4 Comments

The results of testing in Plant D were quite similar to those in Plant C. That is, the urethane-clad screen panels proved to be extremely durable and the small amount of noise reduction measured was due to the condition or layout of the equipment rather than the performance of the elastomer-clad screen decks.

4. CONCLUSIONS

4.1 Summary of Results

This project demonstrated that meaningful noise reduction can be achieved in existing coal preparation plants through retrofit treatments. The treatments tested in this project primarily consisted of resilient screen decks, resilient impact pads, chute liners and curtains.

The initial experience with the resilient screen decks indicated that while they had the potential to reduce the screening noise by 5 to 9 dB (for the eccentric-weight and crank-arm shakers, respectively) there were also some potential operational and durability problems. Specifically these were blinding (primarily evident on the crank-arm shakers) and delamination (primarily evident on the urethane-clad-to-steel decks). supplementary screen deck tests, blinding was not a significant factor in any of the four plants in which the tests were performed, and delamination was only distinctly evident in one of the four preparation plants. Although the service life of the screen decks varied significantly from one plant to the next, the urethane-cast-to-steel decks proved to be particularly durable, providing almost two years of service in one plant and a year and a half in another. In fact, in the latter plant, the panels were eventually removed because of cracks in the steel backing rather than wear of the urethane coating.

The resilient impact pads tested in this project proved to be very effective in reducing the noise generated by large pieces of coal and rock impacting the steel chute walls. Although the durability was found to be heavily dependent on thickness and impact angle, the pads generally provided excellent service. In some cases the profiled rubber impact pads were still serviceable after three years of service.

Of the various types of chute liners tested in this program, resilient liners in closed chutes provided the most effective noise control. The service life of rubber linings ranged from several months in the discharges of the secondary screens to more than 3 years in the Ripl-Flo* discharge chutes. Although rigid chute liners (such as ceramic tiles or ultra-high molecular weight plastics) can be very durable in certain applications, their noise reduction potential is limited and should only be considered (from a noise control point of view) in closed chutes where the chute walls are relatively thin and reverberant.

The loaded-vinyl curtains evaluated in this project proved to be very effective from a noise control point of view (providing 5 to 10 dBA of noise reduction) and quite durable (some installations still providing good service after 4 years). The Velcro closures, when sewn onto the curtains, were also quite durable.

4.2 Recommendations for Future Research

Screening noise is still one of the largest noise problems in preparation plants. While a redesign of the equipment to produce lower noise is the most desirable approach over the long-term, there is still a place for further development of retrofit treatments. In terms of elastomer-clad decks, it would be of significant value to investigate further, the reasons for the plant-to-plant service life differences observed during this project. One area of particular interest is why some elastomer-clad-to-steel screen decks delaminate while other, apparently similar, decks do not. The delamination observed in one of the plants during the second phase of this project indicates that this problem, which was first observed in the Georgetown Plant, is not unique to that plant.

This project has also demonstrated that in order to achieve the full noise reduction potential of elastomer-clad screen decks, it is necessary to reduce the noise produced by the screen drive mechanism. The practicality of doing this on a retrofit basis could also be a promising area of further research.